JANUARY 1984

Vol. 1, No. 4 \$3.95

FOR IBM PERSONAL COMPUTER USERS

TWO VIEWS OF THE LANSCAPE

3Com's EtherSeries and Novell's Sharenet

C COMPILERS REVIEWED

Digital Research, C-Systems, Whitesmith's, Mark Williams

16 MULTIFUNCTION BOARDS FOR THE PC

PC IN THE LAB

USING THE IBM GAME ADAPTER

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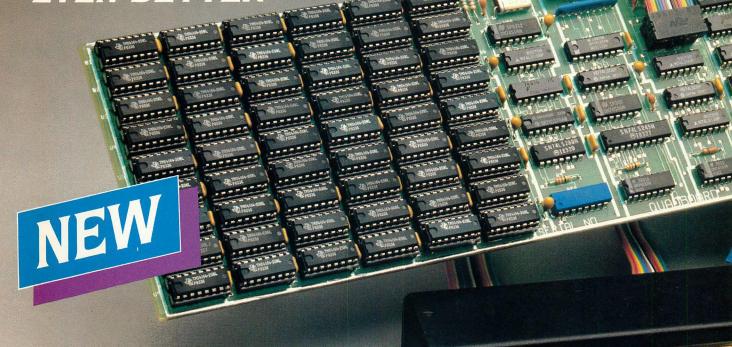
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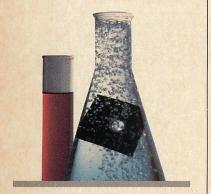
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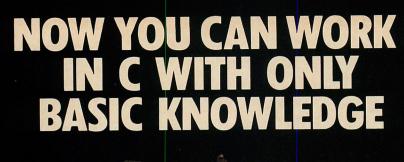
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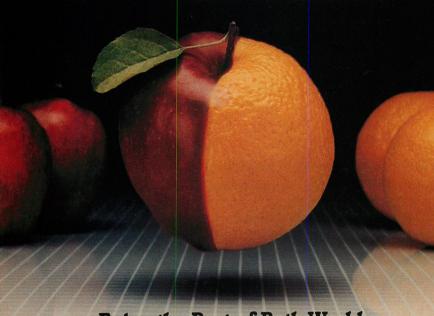
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PC Tech Journal (ISSN 0738-0194) is published 12 times a year, \$29.97 for one year, \$52.97 for two years, \$69.97 for three years. Additional postage \$12 for Canada & Foreign. PC Tech Corp. is a subsidiary of Ziff-Davis Publishing Company. Application to mail at Second-Class Postage Rates is pending at New York, NY 10001. POSTMASTER. Send address changes or subscription inquiries to P.O. Box 2968, Boulder, CO 80321.

Business Offices: Advertising, *PC TECH JOURNAL*, One Park Avenue, New York, NY 10016. 212-725-7947. Subscription inquiries to *PC TECH JOURNAL*, P.O. Box 2968, Boulder, CO 80321.

Editorial Office: PC TECH JOURNAL, The World Trade Center, Suite 211, Baltimore, MD 21202. 301-576-0770. The Source ID STY682.

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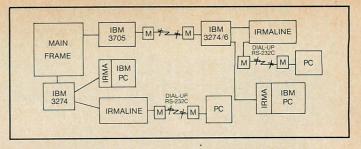
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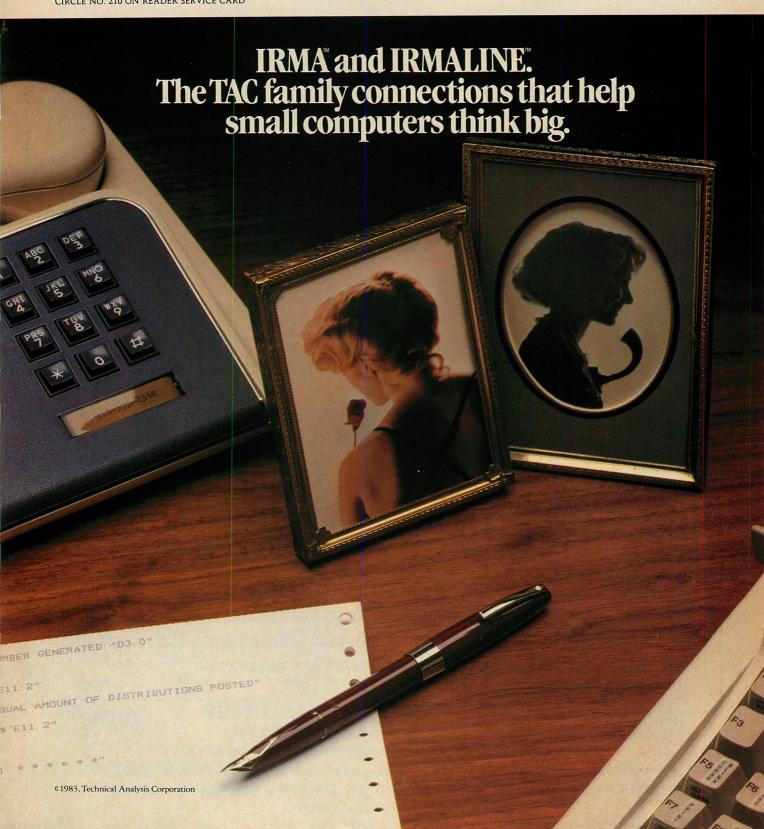
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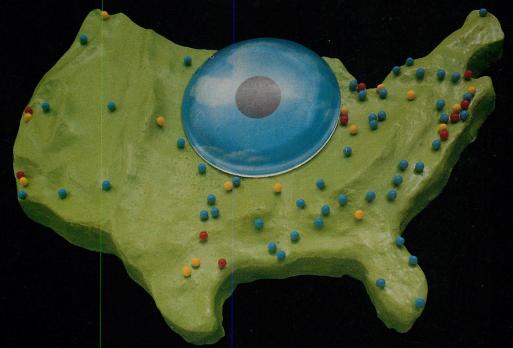
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Its birth, long-awaited and important, has all of us in the magazine business working overtime scrambling for information and trying to beat down IBM doors for loaners. Enough detail about the machine was available for us to include some coverage in this issue (see "Tech Releases" on page 190). We have even had a very brief opportunity to experiment with the machine, albeit superficially. In the process we have learned something about PC TECH IOURNAL that we already knew but had forgotten in our rush to see and touch PCjr: our mission is not one of time, but rather one of detail.

You can count on us to cover new developments as fast as we possibly can. We owe you that. But we know how much you depend on PC TECH JOURNAL for exacting, professional coverage of the IBM-related industry. That takes time, and care. We owe you that too. And that's why you won't find a PCjr review in this issue. Next month? Well, we're trying, but we promise only to run it when we can collect all the information we need to do it right. You can count on that.

We do know quite a bit, even from the limited amount of time we've had with the machine. The problem is that we know almost nothing at our normal level of detail. Let's take a look at some of the questions we all need answered, along with some of the further issues those questions raised.

We can tell you that the new machine uses the same chip set used by the PC. IBM was gracious enough to have a knowledgeable engineer and two open machines at the unveiling. He was very open with information, but of course he was busy answering the same questions over and over. We could see the chip set, but we could not see if they were put together in the same way. Do interrupts and DMA operate exactly the same as in the PC, or is there some subtle difference? If the chips are the same, why won't previous versions of DOS run properly? How does the presence of the cartridge slots affect the boot process? Are they somehow the reason for the incompatibility of other DOS versions?

How about the display adapter? Why do some PC programs that make use of graphics work on PCjr while others fail? Some programs that POKE into graphics memory work on junior; is the same true for those that POKE into the monochrome board's memory? What is the exact nature of that trick on junior? Are there any problems with it? Are the port addresses for the display adapter (specifically the 6845) the same? If not, why, and what is the effect of this

difference on software?

The clock rate for PCjr is the same as for the PC, but junior runs a little more slowly. How come? What effect does this have on programs that depend on execution timing? Is instruction timing on PCjr strictly deterministic or does it vary in some way? If a program uses instruction timing, how can it be developed with precise timings in RAM? Will the timings be the same for a ROM cartridge? Does the system clock operate in the same way, and does it provide any higher resolution?

We could go on, obviously. The common ground of all these questions is PC compatibility, an issue that turns out to be very simple at one level but frighteningly complex at others. The importance of the issue is heightened by IBM's own attention to the matter as indicated by promotional materials (verbal, printed, and video) that push the notion of PC work at the office and PCjr work at home, using diskettes as the interchange media. IBM also provided an extensive list showing which IBM software would and would not operate on junior.

Our own limited experiments demonstrated to our satisfaction a very high degree of compatibility between junior and its parent. The programs I tested all used DOS and BIOS interfaces, and all had real-time requirements, including redirection of certain interrupt vectors and inter-

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But don't take just our word for it. If you need convincing, remember that most of the IBM PCs at Lotus™ are running Hercules Graphics Cards. And the authors of 1-2-3 know a good card when they see one. Or consider that the Hercules Graphics Card is widely used at Rockwell, Mass Mutual, and Carnegie Mellon. They couldn't all be wrong, could they?

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rupt processing. In other words, a clean but complicated interface. We were impressed to see them run. Many other programs, especially entertainment products, either did not run at all or had some difficulty of operation. This was something of a disappointment, but not entirely unexpected given the somewhat greater capability of the machine in the graphics department.

We have come to some conclusions about the machine; most are somewhat obvious. The keyboard is a grave mistake for both its chiclet keys and the infrared link. The connectors on the back are not industry standard and will therefore create some problems. The machine is compact, light, and probably transportable without display. The cartridge slots afford a good opportunity for manufacturers of entertainment software. The machine has a number of

features that make it much better than the PC for graphics and entertainment applications.

These are simple conclusions, ones that anyone might reach. Coming up in PC TECH JOURNAL: the answers to the hard questions.

We're monthly! We hope that excites you as much as it does us. Of course, we're going to be twice as busy building two issues where we used to build one. We hope you continue to enjoy PC TECH JOURNAL and find it as useful as ever. Let us know how we're doing.

We would also like to hear from readers interested writing for us. In our effort to review a wide range of products for the IBM small computer family, we need to broaden our perspective; the best way to do that is to broaden our family of authors. If you are interested, write and tell us what your interests and experiences are. Write to Will Fastie, Suite 211, World Trade Center, Baltimore, MD 21202.

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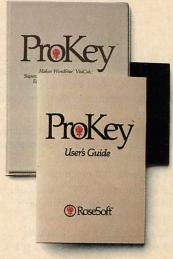
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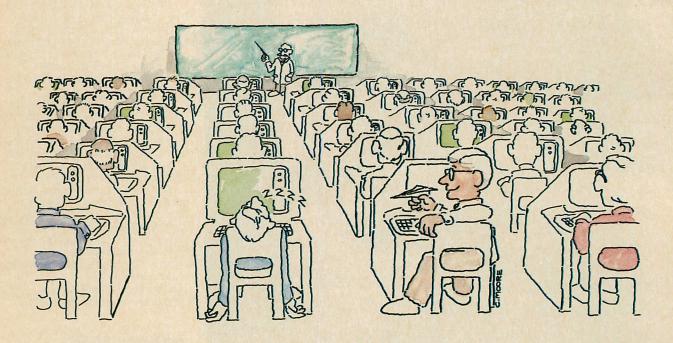
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To run ProKey, you'll need an IBM Personal Computer or workalike, DOS (any version, including 2.0), and 64K of RAM (WordStar requires 96K).

WordStar, VisiCalc, Lotus 1-2-3 and dBase II are trademarks, respectively, of Micro Pro, Visicorp, Lotus and Ashton-Tate.

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Letters to the Editor

WHERE WERE WE?

In Tech Notebook 6 in your September/October issue, you describe how to find out "where you are" in DOS 2.0's hierarchical directory structure. Please see 6-52 of Disk Operating System 2.00, 1/83:

"If you enter CHDIR or CD with no parameters or with only a *d*: parameter, the current directory path of the specified or default drive is displayed."

There are too many serious faults with DOS 2.00 for us to trouble ourselves with nonexistent ones, as you did in your article.

Charles R. Blair, Sr. Townsend, TN

Oops. I won't trouble you with the story of how long I looked for such a feature, or how happy I was to find one. Thanks for the tip.

-WF

COMPARING PRINTERS

The "Epson Technical Comparison" by Arthur A. Gleckler (Sept/Oct) provides a much needed comparison of the most popular printers used on the IBM PC. However, he has missed the most subtle and devastating difference between the IBM Graphics printer and all the other Epson printers with graphics capabilities. In table 1, "Functions common to Epson MX-Ip III, Epson RX-80, Epson FX-80, and IBM Graphics printers" on pages 132 and 133, Gleckler says that all of these printers use the same sequence to "Set line spacing to fn/72inch." In fact, the IBM Graphics printer (and the earlier IBM printer without graphics and the earlier MX-80) uses the "ESC A fn ESC 2" sequence to set the line spacing to fn/ 72-inch. Note that this difference will cause any program that prints multi-line graphics using the "ESC A

fn" sequence to leave a space in the middle of the graphics on one or the other of these printer types. Anyone who writes software to print graphics should not use the "ESC A fn" sequence but should use the "ESC 3 by" sequence, which is, in fact, common for this group of printers. ("ESC 3 by" is not supported on the non graphics Epson type printers, but neither are the graphics.)

One might ask the obvious question: Why did IBM do that? It is my opinion that IBM had to do that to be sure that any software that was written for the earlier printer would work, in the same way, on the newer Graphics printer.

Richard H. Goff Cambridge, VT

EXPLAINING WORDSTAR

In your Sept/Oct 1983 issue (Word Processor File Conversion," Jim Glass states, "WordStar, for reasons known only to MicroPro, adds 128 to the ASCII values of some of the characters in the file."

WordStar turns on the high-order bit for all soft blanks, dashes, and carriage returns to distinguish them from their hard versions.

Similar statements apply to the dash and carriage return. A hard carriage return denotes end-of-paragraph. The user in document mode never needs to hit return to go to a new line, since WordStar will insert the carriage return at the proper place.

Chris Rivers Oakland, CA

DEBUGGING TECH NOTEBOOK 4

I had a problem implementing Tech Notebook 4 (Sept/Oct) DOS 1.1 debug program to see if I had the new or the old 8088 chip. Entering E 100 gets the response XXXX:0100. Spacing following this gets the response 00. The dot cannot be changed to a colon and CO also cannot be entered without getting an error message.

I ended up opening the system to look for the dates on the chip. To save other readers this inconvenience, what is the correct program?

Betty-Jean Lam

Betty-Jean Lamb Los Angeles, CA

You are oh so right. A typographical error slipped into the program. The correct set of commands are these:

—E 100 XXXX:0100 xx.8E xx.CO xx.40 xx.40

-WF

SEPT/OCT

I've just finished poring through your Sept/Oct issue, and I'm writing to congratulate all concerned on an excellent product. Like the Color/ Graphics piece in your first issue, COM and .EXE Files Explained is one of the most useful articles I've seen for the PC. The Tech Notebook pages are also very helpful (although I wish you hadn't helped me to find out that I have one of the bad 8088s in my November, 1982 PC!). All of these articles provided information that isn't being published anywhere else, and they are my only justification for buying PC TECH JOURNAL in addition to my regular purchases of PC Magazine. My only complaint is that it's published too rarely.

> Mark C. Magner Mississauga, Ontario

No sooner said than done. With this month we start the first of our monthly issues of the TECH JOURNAL. As always, we welcome comments from readers and suggestions of articles of interest.

-WF

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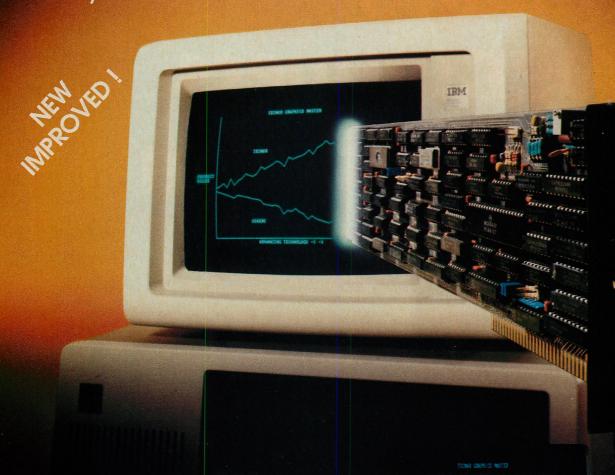
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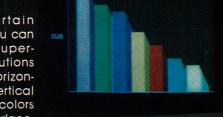
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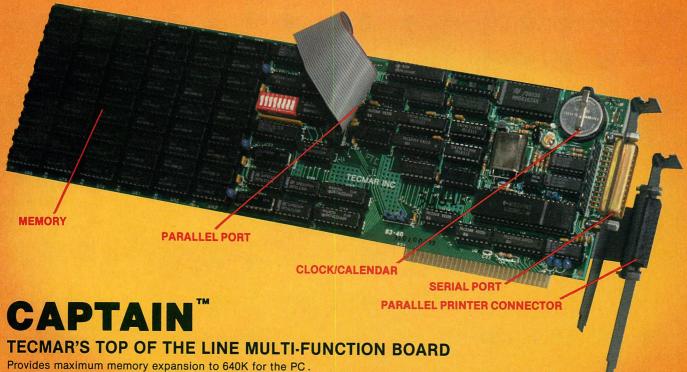
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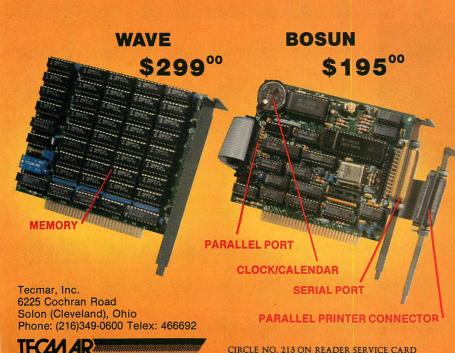
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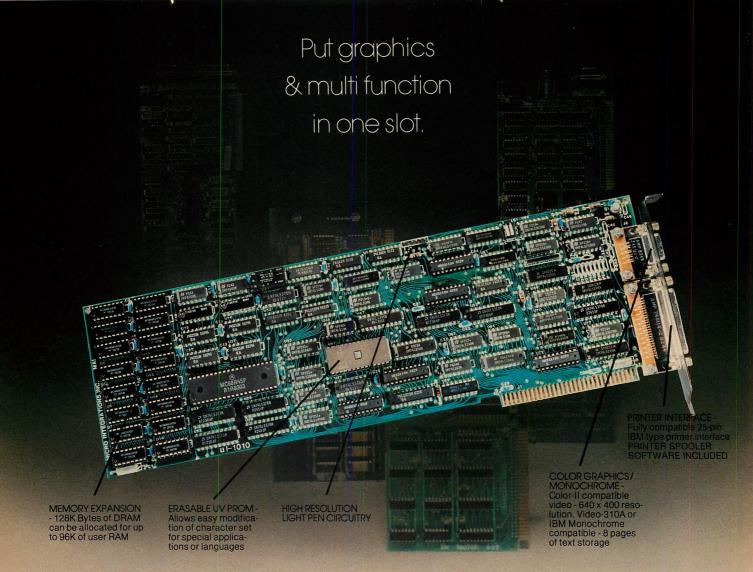
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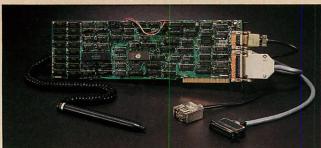
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LETTERS

EDITOR REVIEW, YEA AND NAY

I was somewhat disappointed in your article on text processors (Sept/Oct). The article went to great lengths to comment on hordes of unheard-of editors and overlooked one that puts them all to shame.

I am speaking, of course, of Personal Editor from IBM. Its versatility is unmatched. In scanning down your score sheet, I found that Personal Editor answered "yes" to almost every functional test mentioned. It also has several useful functions that did not make your list.

I have searched in vain for the reason why this was left off your list. The only reason that I have come up with is that it was simply an oversight on your part. In your search to catalog every obscure piece of vegetation in the forest of text processors, you failed to notice the giant oak, IBM's Personal Editor.

John R. Marsland Raleigh, NC

I must admire your courage in subjecting yourself to 18 program editors. That sort of review is most useful for those of us without the time or budget to try all the products available on the market.

Your comments regarding the IBM Professional Editor are for the most part correct, but I have not been able to make it quit without requiring a confirmation input after a file has been modified. If the file has not been modified then a "quit" command will cause an immediate exit, but the file remains intact. Your chart seems to have the correct information, but most people will unfortunately pay attention to the text. Keep up the good work.

William Perlis Birmingham, AL

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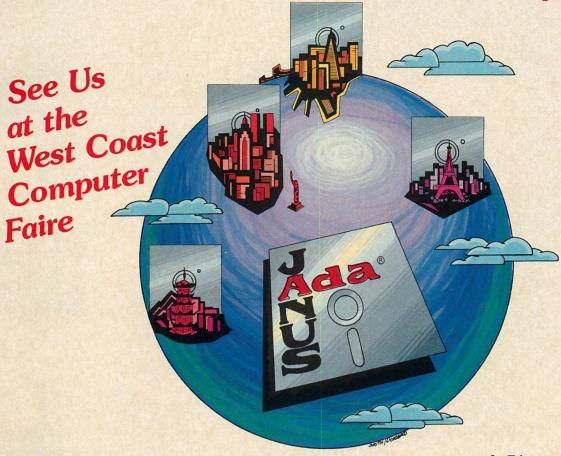
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News, views, and gossip on the IBM and IBM-like marketplace

RANDOM RUMORS

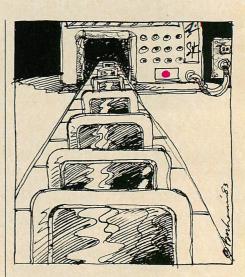
The next version of MS-DOS, currently in development by Microsoft, is rumored to contain such additional features as networking support and multi-tasking capability (à la concurrent CP/M), mouse input, and enhanced graphics capability. Beta testing of version 3.0 of MS-DOS, which was supposed to begin last June, reportedly was pushed back to September, which probably means that 3.0 will now appear in '84, rather than '83. It is still not clear whether version 3.0 will be adopted by IBM for the PC. Sharp Corp., which recently demonstrated a portable computer with an 8-line-by-80-character display, is rumored to be on the verge of introducing a liquid crystal display with a capacity of 24 lines by 80 characters.

Meanwhile, Apple was expected to introduce its long-awaited Macintosh computer in December, with first deliveries to customers expected in January. Expected soon from several vendors are Winchesters with intelligent interfaces that contain microprocessors capable of remicrocoding themselves to adapt to their environment. In other words they would contain their own operating systems. It will be possible with this system for the drive to have a signature marking its lot and manufacture date. This could be used to ward off software pirates. The chip to do this is already in evaluation by disk designers. Gavalin shook the industry with the introduction, in May, of a true, full-function, PC-compatible portable priced at just

under \$4,000. Now there are rumors that a similar machine is due shortly for one-third the price. **Rumored from Microsoft is a plug-in board** for the IBM PC that replaces the 8088 microprocessor with an 80286 true 16-bit unit so users can run their XENIX, UNIX multi-user multi-processing operating system.

Radio Shack is expected, sometime in '84, to bring out a Model 100-like portable that is IBM PCcompatible. It will use a CMOS version of the 8086 that is now available in sample quantities. The Model 100, currently the hottest-selling portable, currently uses the CMOS version of the Intel 8085 8-bit micro. There is a report of an internal IBM **study** that suggests that company revenues from personal computer sales will soon outstrip those of mainframes, long IBM's bread and butter. Expect Artificial Intelligence Corp. to introduce a version of its "intellect" query language for the IBM PC. Franklin Computer Corp., the first company to successfully market an Apple II clone, is expected shortly to introduce an IBM PC-compatible portable system. Look for a 5-megabyte hard disk option for the Columbia Data Products PC-compatible transportable, possibly by the time you read this. Also, Columbia is expected to switch from an aluminum case to a plastic one, to cut at least 4 pounds from its 32-pound "portable." Columbia is also expected to go public sometime next year.

IBM is rumored already signing OEM licenses for its Local-Area Networking protocol. TI and Intel are expected to implement chip sets for this. One hopes that this will



end the current confusion in the LAN marketplace. There are also rumors that IBM and Seagate Technology are working together to develop an ultra-small Winchester (hard) disk drive using 2.75" media and storing 5 megabytes. The next new release of Lotus 1-2-3 is expected in early '84. It likely will add features such as word processing, communications, and an expanded data base manager.

PC-COMPATIBLES DUE FROM ASIA

Several Taiwan and Hong Kong manufacturers of Apple II clones are rumored to be readying IBM PC clones for importation to the U.S. Apple Computer has fought hard to keep its clones out of the country on grounds of patent infringement. On this basis, the U.S. customs service has impounded many units. Apple has also put pressure on foreign governments, who have responded by closing up manufacturers of look-alikes. However, of an estimated 100 clandestine Apple producers in Asia, only a few have been stopped, as many are basement/garage operations. Reportedly an Apple II clone can be purchased in Taiwan or Hong Kong for less

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NEWSLINE

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Copiers seem only too glad to leave the Apple battleground and start copying the PC; after all, there is a bigger market and less harassment. Taiwan Automation, one of the largest electronics producers in Asia, has already announced it will introduce a PC-compatible machine with 256K of RAM and 1000 x 1000 high-resolution display. A portable version will follow. MultiTech International, a distributor of the IBM PC in Taiwan, also was to have introduced a system by the end of '83.

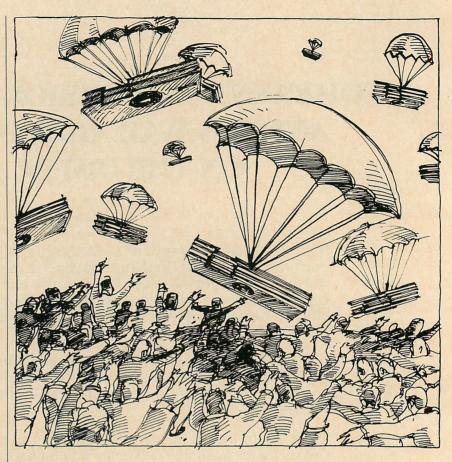
SOFTWARE COMPANIES EXPECTED TO GO PUBLIC

Lotus Development Corp., supplier of the Lotus 1-2-3 integrated spreadsheet package, was the first major supplier of personal computer software to go public. Lotus is expected to be followed shortly by MicroPro International, supplier of WordStar, and VisiCorp, which markets VisiCalc.

Lotus reported that it sold 12,000 copies of 1-2-3 in June alone and that it had a gross profit margin of better than 50 percent on the product, which retails for \$495. Lotus is expected to report sales of over \$40 million in its first full year of business.

MicroPro, which reportedly just barely broke even last year, is expected to report a profit for '83 on expected sales of \$26 million. Word-Star, first introduced in 1978, is the company's best-selling program and has for several years been the leading word processing software package for micros. The Mailmerge program has also proved popular. However, Data-Star and SpellStar, a data-base manager and a spelling checker program, respectively, have not stood up well against the competition.

VisiCorp is currently a one-product company: VisiCalc. VisiCalc was long the leading spreadsheet program on the market. In 1983, however, Microsoft took first place with its Multiplan package, and Sorcim is now running a close third with SuperCalc. Both offer more power and



features, as does Lotus's 1-2-3. Visi-Corp recently responded to this increasingly competitive situation by announcing VisiCalc IV, which includes graphics and sorting features.

VisiCorp is attempting to repeat its success with a new user-friendly front-end software package called *VisiOn*, in development for about two years. It is still not clear whether this package, which is supposed to speed up user productivity, will meet with success (see below). VisiCorp is expected to wait until VisiOn is introduced before it goes public.

VISION, WHERE ARE YOU?

VisiCorp first demonstrated its Visi-On system for the IBM PC a year ago at the November Comdex-West, promising delivery in June 1983. The company continued to demonstrate it at other shows, pushing back delivery time to July, then August, and then October. With luck, VisiCorp will have started delivery of the package by the time this column ap-

pears. VisiOn provides Apple Lisalike features on the IBM PC. It is also rumored that VisiCorp will incorporate a hardware-software lock feature to prevent copying.

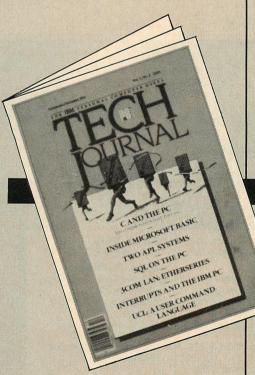
In the meantime, two other companies have demonstrated similar packages (see last issue's column), and Microsoft is expected to release its package momentarily.

It is still unclear whether this graphics-oriented user interface with mouse will increase user productivity, as claimed. And whether it is worth the added cost. A machine equipped with VisiOn, plus comparable applications software, will cost approximately \$10,000, about the same price as the Apple Lisa.

And there is still another significant problem: the lack of application software to run under VisiOn. VisiCorp has recognized this and is starting to conduct seminars for independent software vendors on how to write VisiOn compatible software. The software development toolkit for ISVs will not be available until some-

YVONNE BUCHANAN

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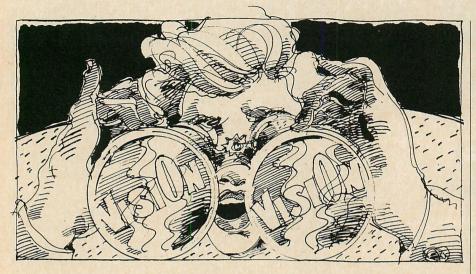
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NEWSLINE



time this year; therefore, I expect that it will be at least a year before we will see a significant amount of VisiOn application software.

On the positive side, VisiCorp has signed licenses with several IBMcompatible system makers, and it is likely that the company will furnish the system with machines having hard disks. VisiCorp has also signed agreements with some on-line database services to provide user interfaces that are VisiOn-compatible.

DISTRIBUTION TRENDS

IBM reportedly now has 1,250 dealers carrying the PC/XT, with close to 60 IBM-owned product centers, up from less than half that number at

the end of 1982. Add to this a few thousand of IBM's own salespeople.

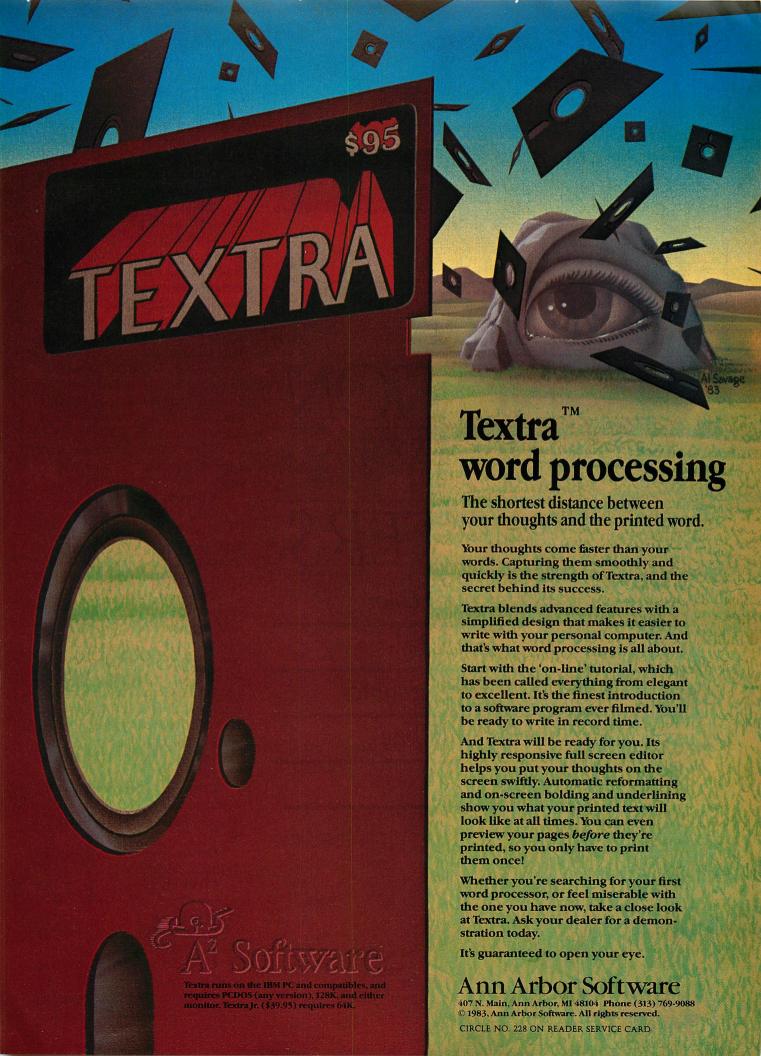
Tandy still leads with an estimated 4,000 Radio Shack stores and 250 computer centers retailing its systems. Tandy also has a small direct-sales staff hawking its 16-bit, multi-user Xenix system to business and industry users.

Apple has about 1,800 dealers and has recently been increasing distribution by letting department stores and hi-fi dealers carry the Apple IIe. Distribution of the Apple Lisa is limited to fewer than 200 dealers and a small direct-sales staff.

In the home computer area, companies such as Commodore, TI, and Atari count sales outlets in the tens of thousands.

Sol Libes is professor of electrical engineering at Union County College in New Jersey. He is the author of 15 books and several hundred magazine articles, and is editorial director of Microsystems.

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HOMAS V. HOFFMANN OUR MULTIFUNCTION DISPLAY ADAPTERS

These devices offer both color and monochrome output, enhance the PC's color graphics capability, and use only one slot in the bargain.

he audience grows impatient as Oscar concludes his presentation. They're anxious to get to the drawing for the door prize.

OSCAR: The IBM color and monochrome display adapters are more than adequate for most PC users. The monochrome adapter and display combination produces a text display system of the highest quality, and includes an integral printer adapter on the display card. The color/graphics adapter sacrifices a little text quality and the printer adapter for a very flexible color text and graphics system. Neither adapter is particularly expensive, and both can be installed in the same PC for a dual display system with excellent text and graphics capabilities. Surely that's everything anyone could want in PC displays.

Enter, stage left, a strange visitor from the East, clad in turban and cape.

VISITOR: Wrong, pixel breath.

OSCAR: Who are you?

VISTOR: Conrac, the Magnificent. May I have the envelope?

OSCAR: Sorry, that's for the door prize.

CONRAC: (takes the envelope anyway): May the boards of a thousand features compete for your slots. May the sixteen colors of the rainbow be forever in your background. May your New Year's Eve be high and your resolution low. May you turn monochromatic with envy, not graphics. May your dog star in "Lassie Goes to Camp Atari."

OSCAR: Atari? You can't be Sirus.

CONRAC: (opens envelope): I wish I were. And Oscar! My, you're a winner, that is what I'd really like to be.

OSCAR: You're really on a roll. Trying to catch up?

CONRAC: I don't relish this, but continue if you must. Hard to see where this leads.

OSCAR: Forget the envelope. The answer is "Shakespeare."

CONRAC: Hey! That's my line. So what's the question?

OSCAR: Who wrote "Display's the thing?"
Exeunt.

ACT TWO

If any of the ills wished upon poor Oscar have befallen you or your PC. then one of these display adapters the Paradise Systems MultiDisplay. the MicroGraphics Technology MasterGraphics, the Amdek Multiple Adapter Interface, or the Tecmar PC-Mate Graphics Master - may be just what the doctor ordered. Each combines the functions of both the IBM Monochrome Display Adapter and the IBM Color Graphics Adapter in a single adapter, and throws in various enhancements and special features, such as more display memory, 16 colors in high resolution graphics. and graphics on the IBM monochrome display, to boot.

As expected, these adapters achieve compatibility with the two standard IBM display adapters by closely following the basic architecture laid down by IBM. Each adapter has a single Motorola 6845 CRT controller chip, dual timing and control logic, and display buffer RAM shared by the display logic and 8088 CPU. Naturally, the display buffer and I/O registers through which the adapters are controlled and monitored have the same addresses and internal arrangement as their IBM counterparts. The great similarity in the basic structure of both IBM adapters greatly simplified the design of these combination adapters, although there are some hairy hardware details.

CONFIGURATION AND COMPATIBILITY

Good news: These adapters are flexible, powerful, and can be configured in numerous ways. Bad news: You have to configure them yourself. Each of the four, for instance, had to be changed before installation; in some cases the boards couldn't have worked at all as set up. The changes weren't necessarily easy to make, but there's more good news: All accompanying documentation is quite com-

plete and well written (MGT's is positively massive, while Tecmar has the best explanation of setting up the 6845 display parameters I've seen anywhere). Figuring out the correct setups took no mental contortion.

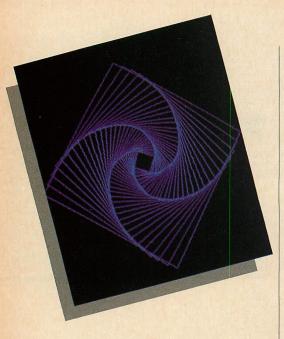
The configuration governs several things. First is the master mode (i.e., which IBM adapter is the one being emulated). The master mode implies the addressing of the display buffer memory, the I/O port addresses, and the possible operating modes (e.g., text, graphics). Second is the ability to be reconfigured. Will the master mode be fixed, or changeable under software control? Fixed mode operation will provide the most compatibility with existing software that expects IBM adapters. It's also necessary if you want to avoid interactions with other display adapters in the same computer. Changeable operation is convenient if you intend to have only one multifunction display adapter and wish to switch between monochrome and color displays within a single program or work session without turning off the computer. Third, configuration governs addressing options for printer interfaces and large display memories.

Programming for these adapters is essentially the same as that for the IBM adapters, once the master mode and addressing is established either by jumpers and switches, or software commands. Next the operating mode must be established by setting the adapter's hardware registers, then the 6845 CRT controller must be set for the desired display dimensions. These details are covered adequately in the accompanying manuals, the IBM *Technical Reference*, and elsewhere, so we won't go into them here.

Paradise Systems has a neat method for establishing the initial master mode at power up or reboot. A three-position switch on the board's end plate selects monochrome, 40-column color, or 80-column color. The switch controls the board's initial I/O addresses (X'3BO-3BF for monochrome, X'3DO-3DF for color). In addition, the switch overrides switches

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DISPLAY ADAPTERS

SW1-5 and 6 on the PC system board (both must be set at OFF), which let BIOS know which display to initialize. Standard IBM software never knows the difference. A jumper plug must be set to either PC or XT, since the switches appear at different I/O addresses in the machines

THE BIG SWITCH

No two adapters have exactly the same combination of features, but they all share one minor drawback: None is capable of displaying on the IBM Monochrome and color display at the same time. To switch from one display to the other you must completely reinitialize the display hardware to select the proper timing and control logic for the desired display.

The Paradise Systems and Micro-Graphics adapters allow both monitors to be connected, although not active simultaneously, with softwarecontrolled switching of the timing and address logic, so switching is relatively painless. The only caveat is that the boards must be completely reinitialized; partial initialization can screw up the signals sent to both displays, producing unstable, indecipherable images. Worse, the IBM Monochrome display is easily damaged by incorrect synchronization that lasts for a prolonged period. If the monochrome display begins to do odd things, turn off the computer.

The MODE command in PCDOS correctly initializes the display adapters, and is the recommended method of switching. The BASIC programs published in the IBM BASIC manual for display switching also work. Some published versions of similar programs (including the one in the MGT documentation!) don't work, so beware. The usual problem is a missing WIDTH 40 immediately before the WIDTH 80: LOCATE, 1, 12, 13 used in switching to monochrome mode. Lotus 1-2-3, and other programs that initialize both adapters once and then modify only the display memory and cursor registers, also will not work with these boards as the only display adapter.

If you need truly simultaneous displays, the boards can be used in pairs (which is expensive), or with a standard IBM adapter (which is less expensive). In either case, software mode switching on the multifunction board should be disabled.

The Tecmar and Amdek boards have only one 9-pin monitor connector, so to switch monitors you have to remove one cable and attach another. The Amdek board doesn't allow software switching of the master operating mode; you have to slide the PC cover forward about four inches in order to get at a tiny switch located on the top rear of the board to change the master mode. Needless to say, this isn't something you'll want to do every few minutes. These boards will tend to spend most of their lives configured one way or the other.

I find simultaneous displays invaluable in graphics development work and would therefore opt for two different adapters: one for fancy color graphics, and the IBM monochrome for text and printer.

PRINTER, PRINTER, WHO'S GOT THE PRINTER?

The Tecmar board alone has no printer interface. The others have a standard IBM printer interface with one very nonstandard feature: The printer address is pegged to the board, whether it is pretending to be a Monochrome Display and Printer Adapter or a Color Graphics Adapter. This is, as are many other things in life, both good and bad. It is also unnecessary, though not obviously so.

A little background: The PC supports up to three printers, called LPT1, LPT2, and LPT3. IBM provides three different sets of I/O ports for printer interfaces. On the Monochrome Adapter they begin at X'3BC, on the separate Printer Adapter, at X'378. If you need a third printer interface, there is a prescribed modification to the Printer Adapter to make the I/O addresses begin at X'278.

When the PC is turned on or rebooted, BIOS checks each printer adapter in the order listed above. The

ith Tecmar, the printer address is pegged to the board, whether it is acting as a Monochrome Display and Printer Adapter or a Color Graphics Adapter.
This is both good and bad.

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DISPLAY ADAPTERS

ll four share one minor drawback: none is capable of displaying on both the IBM Monochrome and a color display at the same time.

first one it finds becomes LPT1, the second is LPT2, and so on. The base I/O address of each printer interface thus discovered is stored in a table at RAM location X'408. The table is four words long, and unused entries are set to zero. (Incidentally, a similar process is executed for communications adapters, with the results stored beginning at X'400.)

A system with a Monochrome Display and Printer Adapter will have LPT1 associated with the device at X'3DC; one with a Color Graphics Adapter and a separate Printer Adapter will have LPT1 at X'378. If both printer adapters are present, then LPT2 will be at X'378.

The multifunction adapters try to establish the same situation: In

wo configuration switches on the Paradise Systems board can be set to any of the three standard printer addresses, or they can disable the printer altogether (in color mode only).

monochrome mode the printer responds to X'3DC; in color mode, to X'378. That's fine for starters. But switching from one mode to the other changes the physical I/O address to which the printer responds without informing BIOS of the change, so subsequent output to LPT1 is lost.

There are several ways around this, short of not switching modes. Rebooting is simple and direct, and probably the best solution for the Amdek board, which otherwise has to have its internal switch flipped and its monitor cable changed. With the MGT board, only direct manipulation of the table at X'408 right after modes are switched does the trick. In BASIC that's spelled

DEF SEG = 0 POKE&H408, &HDC 'for MONO,&H78 for COLOR POKE&H409, &H03

This sets LPT1 to the desired port.

The folks at Paradise Systems have the best solution: Their printer port, like the others, is always at X'3DC in monochrome mode, but the printer address in color mode is determined by two configuration switches on the board. These can be set to any of the three standard printer addresses, or can disable the printer altogether (in color mode only). When you set these switches for X'3DC, the printer address remains constant whatever the mode.

BANKS FOR THE MEMORIES

Each of the four boards has 32K to 128K bytes of memory, compared with the 4K or 16K on the IBM monochrome and color adapters. The extra memory can be used to store additional screens in the standard IBM modes, and provides the required space for the higher resolution extended color modes. At least 4K or 16K, depending on the master mode, must appear in the same part of the 8088 memory address space as in the memory on the standard IBM adapters. Where should the rest go, and why should you care?

IBM has reserved 128K of address space from X'A0000 to X'BFFF for (presumably) video display memory. Boards that confine themselves to this area will be IBM-compatible to the extent that they don't impinge upon other IBM assigned memory. Boards which exceed the area run the risk of battling things like the IBM Fixed Disk BIOS, which lives at X'C8000 through X'C9FFF. Even if a board stays within the IBM video area,

there can be drawbacks: It may conflict with a standard IBM interface coexisting in the same computer. Let's see how the four manufacturers handled this problem.

Paradise Systems had it easy. With only 32K of memory, the board can stay entirely within the 32K space from X'B0000 to X'BFFF reserved for the monochrome display, or the 32K from X'B8000 to X'BFFFF reserved for color graphics. If the board is replacing both adapters, its memory appears in both places in the address space. This technique, called incomplete address decoding, is more commonly used in I/O space, but works with memory as well. When software master mode switching is disabled, the memory responds only to the address range of the corresponding IBM adapter.

The MicroGraphics board's 64K of display memory normally occupies locations X'B0000 through X'BFFFF, encompassing both IBM adapter regions. A jumper allows the memory to be placed from X'C0000 through X'CFFFF. In this configuration the adapter won't conflict with a companion IBM adapter of either type, but it won't be accessible by the standard IBM BIOS software either; you'll have to do all your own programming down to the hardware level. This configuration also conflicts with the Fixed Disk BIOS, and therefore can't be used on an XT or a PC with the expansion chassis. In these cases there's no choice but to have the MicroGraphics board as the only display adapter. If you want to use Lotus 1-2-3 for monochrome test and color graphics you're out of luck, because Lotus doesn't switch master modes the way the MGT board requires.

A nice property of the Amdek board is its extreme simplicity of configuration. Because there is no software switching of master modes, there is no need to enable or disable the function. There are only two switches on the board: one for monochrome/color mode selection, another that affects memory mapping. The

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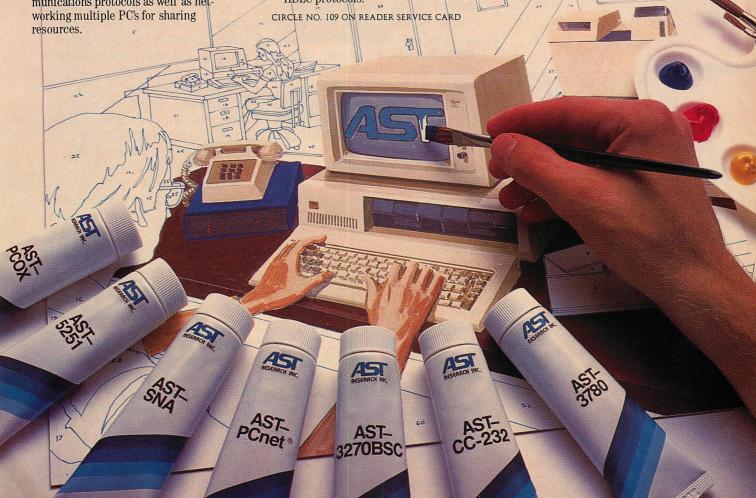


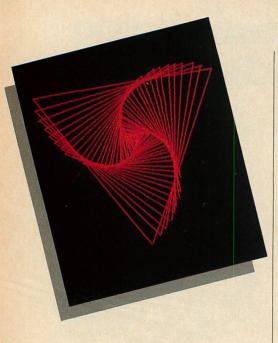




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mdek's 640-pixel
4-color mode is
exactly like the
IBM standard 320-pixel
mode, where each 2-bit
field in memory selects
either the current background color or a color
from the current palette.

DISPLAY ADAPTERS

128K buffer begins at either X'B0000 or X'B8000, depending on the setting of the monochrome/color mode switch. If the second switch is ON only the first 64K is mapped into the video buffer; the other 64K is mapped into user memory at X'40000 (256K). In color mode, this keeps the buffer just below the Fixed Disk BIOS, and also out of the monochrome buffer area, but you give up half of the video pages. If you don't have an IBM fixed disk controller, the second switch can be OFF, giving a complete 128K color video buffer.

Tecmar's board also has a 128K buffer, but with more control over its mapping. The buffer can be thought of as four independent 32K IBM display regions. It is also possible to independently map the buffer so it appears in the 64K space starting at X'A0000, X'C0000, or 'XE0000. A bit in the extended mode register determines which physical half of the buffer appears in the 64K window. Finally, the buffer can appear as a continuous 128K starting at X'C0000. All conflicts can be avoided if you stay away from the X'C0000, and thus. the IBM Fixed Disk BIOS. The prototype demonstration software shipping with my board requires the buffer mapped to 128K at X'C0000. This can't be done on a system with the IBM fixed disk. I hope the final version won't have this problem.

EXTENDED GRAPHICS FEATURES

The three adapters that support extended graphic features (MicroGraphics, Amdek, and Tecmar) do so by similar methods. This is not surprising, because they are all straight-forward extensions of the basic IBM design. Each adapter adds extended mode control bits, and perhaps additional status bits. Three different pixel mappings are used; one bit per pixel, as is used in standard IBM 640-dot graphics; two bits per pixel, as is used in standard IBM 320-dot graphics; and four bits per pixel, which gives the full 16-color graphics.

Amdek, for example, defines the

two high-order bits of the standard mode select register (X'3D8) for memory page selection. These bits are not used in IBM adapters, but here they determine which 32K section of the 128K display buffer will be the starting point for the current display image. Finer control is achieved by setting the 6845 Start Address registers.

Amdek's two additional colormodes are 320 by 200 with 16 colors (two pixels per byte) and 640 by 200 with 4 colors (eight pixels per byte). These are achieved by setting bit 0 of the mode register to 1 for high resolution, a natural interpretation of the meaning of the individual standard mode bits. The 640-pixel 4-color mode is exactly like the IBM standard 320-pixel mode, where each 2bit field in memory selects either the current background color or a color from the current palette. The 16color mode uses 4-bit fields, two per byte, which determine pixel color in the same way as the 4-bit fields in the alpha mode attribute byte do.

The MicroGraphics and Tecmar adapters both support 640-dot 16-color modes, using the four-bit-per-pixel mapping. MicroGraphics doesn't support the 640-dot 4-color.

A short digression. Having used Amdek as an example, because its mode selection is the least complex. and therefore easiest to describe, I now feel free to air a small complaint. Amdek's documentation indicates that in monochrome mode, the page elect bits in the mode register are "not used (must be 0)." Nonsense! If they're not used, they can be anything at all. If they must be 0 for the thing to work right, then they are used. You can't have it both ways. I'm not trying to pick on Amdek-IBM is notorious for this kind of documentation, and everyone has done it sometime (even I have, possibly in this magazine) - but it irks me to see such an obvious falsehood expressed so concisely. Perhaps they were only following Appelbaum's First Dictum of Documentation: "Never let truth stand in the way of clarity."



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Character Generator Organization

The IBM Color Graphics adapter and Monochrome Display and Printer adapter have intentionally similar designs. Both use the Motorola 6845 CRT controller chip, the I/O registers are organized almost identically, and they use the same character generator ROM. The organization of data in the character generator is interesting to those who may wish to replace the ROM with a compatible PROM to have a custom character set available in text modes. Users of the MicroGraphics board can actually read the contents of the character generator to avoid having to duplicate the patterns in user memory for making characters in graphics modes.

The character generator is an 8K byte ROM, containing three distinct sets of patterns for the IBM 256 character set. Two sets are for the color/graphics adapter (or master mode on the multifunction cards), the other is for the monochrome adapter. Figure 1 shows the organization of the character generator. The first 2K contains patterns for the top eight rows of the monochrome 7-by-9 dot character set. The next 2K contains patterns for the bottom eight rows, only the first six of which are

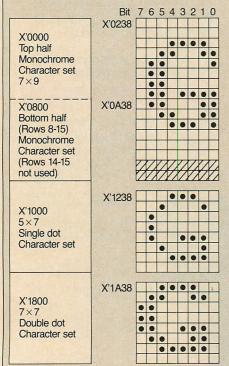


Figure 1: Character Generator Organization

used. The third and fourth 2K segments contain patterns for the 5-by-7 single dot characters and the 7-by-7 double dot characters used in color/graphics mode.

You may wonder why the character sets are called 7 by 9, 5 by 7, and 7 by 7 when the patterns are in fact 8 by 16 or 8 by 8. The sets are named for the dimensions of a standard upper-case character, not for the area in which they lie. In fact, the monochrome adapter displays characters in a 9-by-14-dot cell, which is one dot wider than the pattern. More about that in a moment.

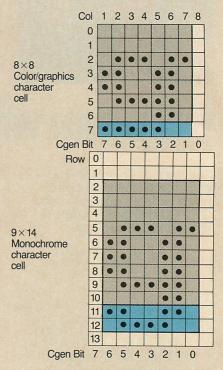
The terms single dot and double dot refer to the style of the character patterns, not the size. In the 5-by-7 single-dot font, vertical segments may be only one dot wide. In the 7-by-7 double-dot font, no vertical stroke is narrower than two dots. Another way of putting this is that in the double-dot font, no horizontal row requires the electron beam to make a transition more frequently than every two dot times. This puts less of a demand on the display bandwidth, and leads to better images on low resolution displays.

The double-dot font is standard on the IBM color adapter. A place for a jumper is provided in a box labelled P3 near the lower left corner of the 6845 chip. A jumper installed between the two contacts should select the single-dot font, giving sharper definition on high resolution monitors. Warning: this information is based on published IBM technical data, not on actual experiments. This modification should be made by a qualified technician, preferably in such a way that it can be undone easily.

The Dots that Aren't There

The monochrome display adapter puts the 8-by-14-dot pattern from the character generator in a 9-by-14 cell (see figure 2). Generally the ninth column is blank and contributes to the space between adjacent characters. Some characters, such as those in the line-drawing character graphics set, must extend across the entire width of the character cell in order to connect with adjacent characters. How is this done?

The IBM monochrome adapter contains logic that treats character codes X'CO through X'DF in a special way. For these characters, the ninth column is copied from the eighth column (the



Standard character area Lower case descenders

Figure 2: Character Cell Layout

low order bit in the character pattern byte). If you examine the character table (such as the one in Appendix G of the IBM BASIC manual), you'll see that the characters with rightward extending lines, or those that fill the right edge of the cell, are in this range. Unfortunately, the block-shading characters (X'BO through X'B2) are outside this range, and don't fill the cell.

The Amdek board displays the shading characters so that they do fill the cell, a welcome improvement. The prototype MicroGraphics board that we received extended character codes X'BO through X'CF into the ninth column. While consistent with the accompanying documentation, this is incorrect, because it leaves out most of the characters intended to extend to the extreme right of the cell, resulting in broken lines where there should be solid ones. Presumably this will be fixed in production models, but it's worth checking. Incidentally, MicroGraphics was the only one of the four vendors whose documentation even discussed the character generator. It even included pictures of all three character sets. MicroGraphics also plans to offer an auxiliary PROM programmer so that you can make your own custom character sets.



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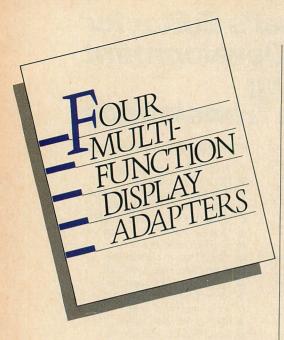


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f you're conserving slots and dollars, can live without simultaneous displays, and don't need any extended display modes, the Paradise Systems board is a reasonable choice.

DISPLAY ADAPTERS

CONCLUSIONS

If you're conserving slots and dollars, can live without simultaneous displays, and don't need any extended display modes, the Paradise Systems board is a reasonable choice. It's the only one of the four that costs less than the equivalent pair of IBM adapters, and is the product most compatible with IBM software.

For graphics on the IBM monochrome display, the MasterGraphics and Tecmar boards are my choices. The MasterGraphics board is \$116 less than the Tecmar, and has some specialized animation support. The Tecmar board has twice the memory (128K), and can be adapted to work with external video sources to superimpose computer images on live video. OEMs and TV stations might find this capability useful.

If maximum memory and color graphics are your goals, the field is narrowed to Amdek and Tecmar. The Amdek board is \$96 cheaper. and has a printer interface built in. But it lacks monochrome graphics and its software cannot be reconfigured easily. The Tecmar board has more flexibility when it comes to display formats, but is more complicated to set up in some of the extended modes; its memory organization is particularly complex, though the documentation provides tables that enumerate the possible setups. Amdek has a unique high resolution extension to the light pen interface, which allows positioning to the nearest pixel instead of plus-or-minus-four pixels as with the standard interface. Tecmar has an RF modulator connector for connecting standard television receivers, but it's so close to the light pen connector that you cannot get both of them on at the same time.

The Halo graphics software supplied with the Amdek board is said to be extremely flexible and powerful (it was not available in time for this review). It includes such features as windowing, clipping, line styles, dithering, three different fill algorithms, text in varying sizes and orientations, and more. Tecmar sup-

plies a smart terminal driver for DOS 2.0 that understands escape sequences for a variety of text, line, and graphics commands. Software to drive the MicroGraphics board is also coming.

Certainly none of these boards is clearly superior to the others in every circumstance (see table 1). Your own needs and prejudices will have to guide you. I like them all.

Paradise Systems Multi-Display Adapter

Paradise Systems Inc., 150 North Hill Drive, Suite 10, Brisbane, CA 94005. 415-468-5320. \$495. CIRCLE 462 ON READER SERVICE CARD

MicroGraphics Technology MasterGraphics Adapter

MicroGraphics Technology, 1820 McCarthy Blvd., Milpitas, CA 95035. 408-996-8423, Ext. 421. \$579.

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Amdek Multiple Adapter Interface

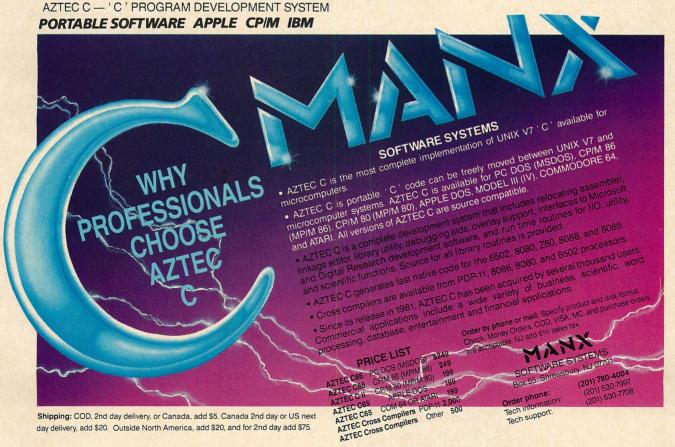
Amdek Corporation, 2201 Lively Blvd., Elk Grove Village, IL 60007. 312-364-1180. \$599.
CIRCLE 464 ON READER SERVICE CARD

Tecmar PC-Mate Graphics Master

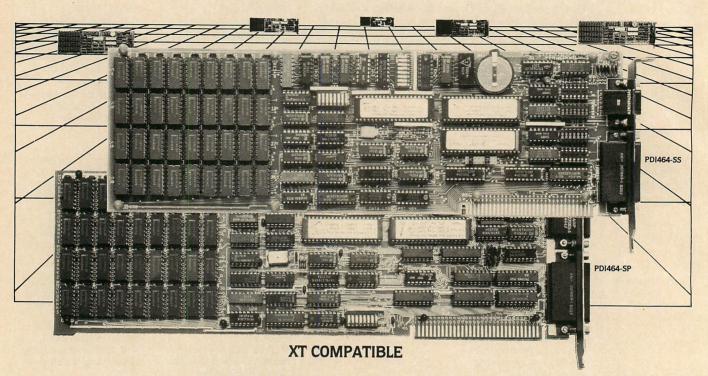
Tecmar Incorporated, Personal Computer Products Division, 6225 Cochran Road, Cleveland, OH 44139. 216-349-0600. \$695. CIRCLE 465 ON READER SERVICE CARD

Thomas Hoffmann is a contributing editor to this magazine.

Table I: Features at a Glance								
	Paradise Systems MultiDisplay Adapter	MicroGraphics Technology MasterGraphics Adapter	Amdek Multiple Adapter Interface	Tecmar PC-Mate Graphics Master				
Construction Connectors	Dual piggy-back PC card IBM monochrome display (9-pin); RGB monitor (9- pin); Composite moni- tor (RCA phono); Light Pen (6-pin strip); Parallel Printer (25-pin)	Dual piggy-back PC card IBM monochrome display (9-pin); RGB monitor (9-pin); Light Pen (6-pin strip); Parallel Printer (25-pin)	Single PC card IBM monochrome display or RGB monitor (9-pin); Light Pen (6-pin strip); Parallel Printer (25-pin)	Single PC card IBM monochrome display or RGB monitor (9-pin); Composite monitor (RCA phono); RF modulator (4-pin strip); Light Pen (6-pin strip)				
External Switch	40/80 color, mono (3 position). Sets initial hardware master mode.	NO	NO	2 position, software read- able. No direct effect on adapter hardware.				
Software Mode Set	YES	YES	NO	YES				
Memory	32K	64K	128K	128K				
Monochrome Graphics	NO	720 by 350, 2 screens	NO	720 by 350, 2 screens 720 by 700,?				
Extended Color Graphics	NO	320 by 200, 16 colors, 2 screens 640 by 200, 16 colors, 1 screen	320 by 200, 16 colors, 4 screens 320 by 400, 16 colors, 2 screens 640 by 200, 4 colors, 4 screens 640 by 400, 4 colors, 2 screens	320 by 200, 16 colors, 4 screens 640 by 200, 4 colors, 4 screens 640 by 200, 16 colors, 2 screens				
Special Features	1. Optional suppression of display blanking in color mode for reduced flicker. 2. Printer address can be fixed by option switches. 3. Horizontal and vertical sync pulse polarity independently controlled by option switches.	Interrupt on start of field for animation support. CPU can read character generator ROM.	1. 64K of memory can be mapped to user memory at X'40000 (256K). 2. High resolution light pen interface (½ to 1 pixel resolution). 3. Price includes Halo ™ graphics software and low level print spooling software.	Provision for external sync to allow combining images with other video sources. Most flexible display format combinations, with independent control of mode and dot clock rate.				



Plug Pure Data



If you're looking for a multifunction board, you're faced with a bewildering array of functions, manufacturers, and prices. It's important to select the right card for your present and future needs. Pure Data offers a variety of highquality expansion boards designed for the utmost in reliability and flexibility. We invite you to make comparisons with other brands. Our support software and documentation is the most complete available. Surprisingly enough, our products cost a lot less than you would expect. All of our IBM Personal Computer products are covered by a one

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PDI464-SP

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- Highest quality ceramic RAM chips used throughout
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- IBM-compatible parallel printer adaptor with selectable address
- Real Time Clock/Calendar with field-replaceable lithium battery backup

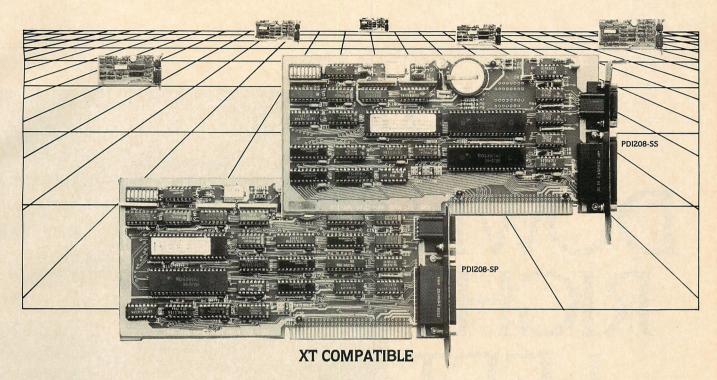
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- p-DiskTM disk emulator for single/double-sided diskette emulation
- Print spoolers for parallel and serial channels with multiple copies
- Software for clock support, dynamic memory configuration, memory testing
- Only occupies one expansion slot
- Fully-illustrated installation and operation manual

PDI464-SS

- Up to 256K of RAM, fully socketed, with parity generation/ checking
- Highest quality ceramic RAM chips used throughout
- Two IBM-compatible serial channels with selectable addresses, 6-foot cables

into your PC!



- Serial channels feature modem/ printer configuration jumpers
- Real Time Clock/Calendar with field-replaceable lithium battery backup
- p-DiskTM disk emulator for single/double-sided diskette emulation
- Print spoolers for parallel and serial channels with multiple copies
- Software for clock support, dynamic memory configuration, memory testing
- Only occupies one expansion slot
- Fully-illustrated installation and operation manual

PDI208-SP

- IBM-compatible serial channel with selectable address and 6-foot cable
- IBM-compatible parallel printer adaptor with selectable address
- Real Time Clock/Calendar with field-replaceable lithium battery backup
- p-DiskTM disk emulator for single/double-sided diskette emulation
- Print spoolers for parallel and serial channels with multiple copies
- Software for clock support, dynamic memory configuration, memory testing
- Only occupies one expansion slot
- Fully-illustrated installation and operation manual

PDI208-SS

- Two IBM-compatible serial channels with selectable addresses. 6-foot cables
- Real Time Clock/Calendar with field-replaceable lithium battery
- p-DiskTM disk emulator for single/double-sided diskette emulation
- Print spoolers for parallel and serial channels with multiple copies
- Software for clock support, dynamic memory configuration, memory testing
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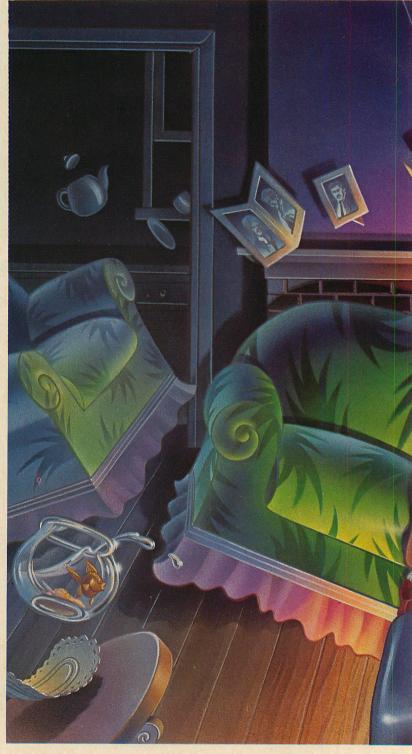
P.O. Box 815155, Dallas, Texas 75381

Keysoft International, Computerland, Computer Innovations, Compugroup, ECOSEA Technologies and others.

DOWN, RIGHT, LEFT, CHECK

Part one of a guide to using the IBM Game Adapter from BASIC and Assembly language

ith a machine as complex as the PC, it would be easy to view the Game Adapter as an afterthought. For one thing, it concerns joysticks, and joysticks are for games—everyone knows that the PC





GARY CICCARELLI

is a serious machine. Compared with equipment such as the Color/Graphics Adapter, mega-combo cards, and Winchester disks, how complex can the Game Adapter be? You just see whether it's up, down, right, or left, and check the button, right?

Wrong. It just isn't that easy. Although the Game Adapter is relatively uncomplicated and used mostly for games, a number of tricks to its use can mystify even the advanced programmer. Moreover, the use of the Game Adapter varies depending on the language used. Finally, characteristics of the 8088 microprocessor and the use of varying brands of joysticks muddy the water a bit more. Fortunately, the Game Adapter is simple enough that these problems can be handled by the proper software.

This is the first part of a two-part guide to the use of the Game Adapter from BASIC and assembly language. Starting with an overview of Game Adapter hardware and operation, we will cover possible applications and then discuss the joysticks available off-the-shelf for use with the Game Adapter. We then discuss the various ways to monitor the Game Adapter state from BASIC, with an illustrative program and a sample application. Part two of the article, which will be carried in the February issue of PC TECH JOURNAL, will cover reading the Game Adapter inputs using assembly language. It will include two illustrative programs.

OVERVIEW OF THE GAME ADAPTER

The Game Adapter is a plug-in card that allows the PC to monitor certain conditions in the outside world. It fits into any of the five expansion slots in the IBM PC. Although it is not clear why, IBM recommends installing the adapter in slots 1, 2, or 4. The Game Adapter is far shorter than most adapter cards, so slot 1, the leftmost slot, is a good location because a longer board would muffle the PC by partially blocking the internal speaker.

The Game Adapter accepts four

resistive inputs and four digital inputs, which are attached through a female, 15-pin D shell connector that protrudes through the back panel of the PC. The resistive inputs are usually variable resistors that are attached to joystick handles, and the digital inputs are generally joystick buttons. This allows up to two joysticks, each with two buttons, to be attached to the Game Adapter.

APPLICATIONS

Not too surprisingly, the Game Adapter is used mostly for games. Perhaps if IBM had chosen to call it the "X-Y Controller Adapter," the adapter would not be so stereotyped, but games, particularly arcade-style games, constitute the vast majority of the applications for the adapter. There are, however, more serious applications for the Game Adapter.

One such application is in the area of drawing and design programs. While the cursor keys on the PC can indicate motion in only four directions, a joystick can indicate motion in any direction in a straight line to any part of the screen. With the Color/Graphics Adapter, or a similar add-on board, the PC is capable of becoming an artist's canvas, with a joystick functioning as the paint brush.

Unfortunately, experience has generally shown that a joystick is not as effective a controller in drawing and design applications as one might think. Simpler drawing systems generally use the keyboard, while sophisticated programs normally use a drawing tablet or a light pen.

The Game Adapter can also be used to control menu selection. A joystick or paddle is used to move the cursor to the desired screen location and a button pressed to initiate action. In fact, the two buttons that have become a *de facto* standard on the PC considerably enhance the usefulness of joysticks on the PC.

While joysticks are the most frequent additions to the Game Adapter, other devices can also be attached for certain purposes. For example, an

electric eye could be attached, perhaps consisting of a CdS (cadmium sulphide) photocell, the resistance of which varies with the light level. The appropriate software in the PC could then respond to events such as

Ithough the Game
Adapter is relatively uncomplicated
and used mostly for games,
a number of tricks to its use
can mystify even the advanced programmer.

the breaking of a beam of light, or the darkening of a room.

Another alternative is a knob attached to a variable resistor. This knob could be used, for instance, to control the speed of operation of a simulation program. The knob would be turned one way to run the program at top speed, and in the other direction to slow the program so that the simulation could be observed in leisurely detail. Any software that might benefit from variable speed of operation could use such a dial.

A final, somewhat trivial Game Adapter application would be a multiple-choice quiz board with four big switches, one for each of four possible answers. Each of these switches would be attached to a digital input of the Game Adapter. Appropriate software could present questions on the screen, and then monitor the Game Adapter for the answer selected. This application illustrates the variety of potential special applications for the four resistive and four digital inputs to the Game Adapter, beyond the perception that it is merely a "joystick adapter." (As an interesting aside, IBM refers to the board as the Game Adapter. However, the board has the legend "analog input card.")

ADAPTER AT WORK

A Game Adapter and one or two joy-

sticks form a single functional unit. (If one joystick is attached, it is joystick A; a second joystick, if present, is called joystick B.) The two joystick resistances vary with the position of the joystick handle in each of the x and y directions. The Game Adapter and appropriate software then convert these resistances to two numbers that indicate the position of the joystick handle in each of the x and y directions; if joystick B is attached, two more numbers indicate the location of its handle. In the x direction, the values are lower when the joystick handle is toward the left and higher when it is toward the right; in the y direction, numbers are lower when the handle is toward the top and higher when it is toward the bottom.

It is important to understand that any one of a whole range of numbers can be returned in each coordinate. No one number means "right" or "left," and so on; rather a range of numbers say, from 1 to 200, with 1 being toward the left, 200 being toward the right, and intermediate numbers representing intermediate positions. Fifty would be toward the left, 40 even more so. Picture the joystick handle as moving in a grid, with (0, 0) at the upper left; the two numbers returned for each joystick describe the location of the handle in that grid. The higher the resistance in the joystick, the greater the range of numbers that can be returned; the significance of this follows.

Joysticks that return a continuous range of numbers are known as cursor-type joysticks, presumably because it was thought that they would be used to move directly the character cursor about the screen. In practice, however, human hands are too unsteady for joysticks to work well in this manner, except for applications which require a limited number of cursor locations. (Listing 3 is such an application.) Most game computers use switch-type, rather than cursororiented joysticks. Switch-type joysticks return only a number indicating the joystick's direction (left, right, up, down) instead of the exact location of the joystick.

The Game Adapter returns one number for each button if the button is up and another if it is down. This system is far simpler than checking the joystick handle location, particularly from BASIC.

AVAILABLE GAME ADAPTERS AND JOYSTICKS

A number of off-the-shelf Game Adapters and joysticks are currently available, and all are not alike.

The basic IBM Game Adapter card performs only the functions of the Game Adapter, and, as stated, uses one of the five available expan-

oysticks that return a continuous range of numbers are known as cursor-type joysticks, presumably because it was thought that they would be used to move directly the character cursor about the screen. In practice, however, human hands are too unsteady for joysticks to work well in this manner, except for applications that require a limited number of cursor locations.

sion slots. Many multifunction boards for the PC contain the functional equivalent of the Game Adapter in addition to memory, asynchronous ports, clocks, and the like. Since expansion space is so limited, and in view of the fact that the joystick circuitry requires only a few square inches of circuit board space, such a multifunction card is a sensible way to add a Game Adapter. This article applies fully to these boards.

IBM does not market a joystick for the PC, an unfortunate fact, be-

cause such a product would almost certainly become an industry standard for the PC. What have developed, instead, are several regrettably dissimilar joysticks from a number of manufacturers. On most microcomputers (the Apple II, for instance) there is a standard resistance range for joystick variable resistors, so that a program can safely assume that one joystick will be much like another. Not so on the PC. Joysticks with at least three different ranges of resistance are on the market, and many manufacturers complicate matters further by providing adjustment slides. There are PC joysticks with ranges of 0-100k ohms, 0-150k ohms, and 0-250k ohms. This means that PC programs can make no assumptions regarding the range of numbers that will be returned by a joystick and should explicitly check and calibrate each joystick at least once. (Remember that the higher the resistance in a joystick, the greater the range of values returned.) The Technical Reference manual specifies that 0-100k ohm variable resistors be used, but this is one case where IBM seems to have been ignored.

Off-the-shelf PC joysticks are otherwise fairly standard. They are all cursor-oriented models, with variable resistors in each of the x and y directions. PC joysticks generally also have two slide switches that can be used to fine-tune the resistance of the joystick. These joysticks have two buttons and attach to a standard connector on the Game Adapter or equivalent on the back of the PC. Lastly, joysticks on the PC are usually self-centering - that is, they return to the center position if released. On some models, however, the self-centering springs can be detached.

The joystick connector on the Game Adapter is not compatible with the joystick port on any other popular microcomputer, so joysticks or paddles for other computers can not be used with a PC without rewiring. In fact, it is possible to modify some non-PC joysticks to work with a PC.

but it is rarely worth the effort.

The PC Game Adapter is capable of handling two joysticks through the single connector at the back of the computer. However, in order to combine the cables for each of the two joy sticks, Y-connector cable is used.

A popular controller on the Apple II is the paddle controller, a handheld device with a knob and single button, ideal for controlling one-dimensional motion. There is no reason why up to four paddle controllers with one button each could not be used with the Game Adapter, save for the fact that, to the best of our knowledge, no paddle controller has ever been marketed for the PC. It should certainly be possible to modify a paddle controller designed for another machine for use with the PC, but because PC software is designed for use with joysticks, and because joysticks are generally more versatile. paddle controllers are effectively a dead issue on the PC.

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READING THE JOYSTICK FROM BASIC

By returning numbers that indicate the joystick handle positions and the joystick button states, BASIC simplifies considerably the task of reading the joystick. But it does not do all the work for the programmer. Specifically, it is totally up to the programmer to interpret the number returned by BASIC for the handle position (that is, what joystick positions the numbers returned correspond to).

The STICK and STRIG functions and the STRIG statement are the simple, general-purpose joystick-related commands contained in all versions of BASIC on the PC. The ON STRIG and STRIG(n) statements, which provide quicker, more flexible response to the joystick buttons, are available from Advanced BASIC only. Commands standard to all versions of BASIC are covered below.

THE STANDARD JOYSTICK COMMANDS

The STICK function is the one command used to determine the location of the joystick handle from BASIC. The STICK function is

x = STICK(n)

where *n* indicates which of the resistive inputs is to be returned. Valid *n* values are these:

- 0 to return the x value of joystick A.
- 1 to return the y value of joystick A.
- 2 to return the x value of joystick B.
- 3 to return the y value of joystick B.

The values returned are proportional to the joystick location in the specified coordinate. The farther to the right or to the bottom the joystick is, the higher the number. The values returned are never higher than 255. For example, if

STICK (0)

were executed, the number returned would be close to 0 if the handle of joystick A were near the left, and would be closer to 255 if the handle were near the right. The precise values depend on the resistors in the joystick; the larger the resistors, the higher the maximum values. We will explain the calibration of the joystick and the interpretation of the values returned below. Incidentally, if the resistance is so high that the count would exceed 255, BASIC discards the result as invalid and reuses

the last valid value. We've seen some joysticks that do, in fact, produce this high count when their adjusting slides are not centered.

There is one trick to the use of the STICK (n) statement. Whenever

STICK (0)

is executed, all four joystick coordinates are read, and the value of the x coordinate of joystick A is returned. Whenever a STICK is executed with a value of 1, 2, or 3, the value returned is that of the corresponding coordinate at the time of the last STICK(0); that is, only STICK(0) actually reads the joystick, and it reads all four resistive inputs. This characteristic can result in the use of old and irrelevant joystick readings if the programmer is not careful.

The joystick buttons are read with the STRIG statement and the STRIG function. Before the buttons can be tested, the statement

STRIG ON

must be executed. After this, each time BASIC starts to process a new command, the joystick will be checked for the button state. BASIC then remembers whether a button has been pressed; you can check this with the STRIG function. (STRIG OFF disables the checking of the joystick buttons.) The STRIG function is

x = STRIG(n)

where *n* is in the range 0 to 7. There are two separate sets of action, one for even values of *n* and one for odd. If *n* is odd, the current state of the specified button is checked; if *n* is even, the state of the button since the last STRIG(*n*) is returned. Thus, if *n* is odd, the actions are:

- 1—returns -1 (TRUE) if button 1 on joystick A is pressed, 0 otherwise.
- 3—returns -1 if button 1 on joystick B is pressed.
- 5—returns -1 if button 2 on joystick A is pressed.
- 7—returns -1 if button 2 on joystick B is pressed.

The values returned can be tested for TRUE or FALSE with an IF . . . THEN statement.

If n is even, the actions are:

- 0—returns -1 (TRUE) if button 1 on joystick A was pressed since the last STRIG(0) was executed, 0 otherwise.
- 2—returns -1 if button 1 on joystick B was pressed since the last STRIG(2) was executed.
- 4—returns -1 if button 2 on joystick A was pressed since the last STRIG(4) was executed.
- 6—returns -1 if button 2 on joystick B was pressed since the last STRIG(6) was executed.

With *n* equal to 0, 2, 4, and 6, you do not have to worry about missing the depression of a joystick button; once a STRIG ON statement is executed, BASIC checks at the beginning of every command for you. (If a STRIG OFF is in effect when a STRIG(*n*) function is executed, an Illegal Function Call error results.)

Strangely enough, Cassette and Disk BASIC seem only able to handle *n* from 0 to 3, so only one button from each joystick may be read. This may be fixed in later versions of BASIC than 1.10; if you have 128K or more of memory, there is no reason not to use Advanced BASIC in any case.

AN EXAMPLE OF STICK AND STRIG

The program shown in listing 1 (following this article) uses the STICK and STRIG functions to constantly monitor the state of whatever inputs might be attached to the Game Adapter card. The assumption is made that the resistive inputs are joystick resistors and the digital inputs are buttons, as specified in the Technical Reference manual.

The STRIG ON statement in line 70 is necessary to enable BASIC to

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constantly check the state of the buttons. Any BASIC program which uses the joystick buttons must execute a STRIG ON statement before any STRIG(*n*) function can be executed.

The STICK(0) function on line 80 returns the reading for the x coordinate of joystick A. This also takes the reading for the other three resistive inputs, the y coordinate of joystick A and both coordinates of joystick B. STICK(0) should be executed immediately before STICK(1), STICK(2), or STICK(3), since the latter do not actually cause a reading to be taken but rather use the reading taken when the STICK(0) was executed. Line 90, then, reads the other three inputs to the Game Adapter immediately after the STICK(0).

Line 100 monitors the state of each of the buttons with the STRIG function. If the program used the odd values, 1, 3, 5, and 7, as parameters to the STRIG function, then this line would only check to see whether the buttons were depressed at the instant that the STRIG was executed. Because even parameters are used, the STRIG(n) functions determine instead whether a button has been depressed since the last STRIG(n), so that the program will not miss buttons that are only briefly depressed.

The remainder of the program displays the results of the STICK and STRIG functions. Line 190 ends the

program if any key is struck.

When you run the program in listing 1, you will notice that there is often an appreciable delay between the depression of a button and the corresponding change in the screen display. This occurs because BASIC takes quite some time (by computer standards) to execute all of lines 80 to 190. If you push the button when, say, line 110 is executing, then 11 lines must be executed before the program arrives back at a STRIG function that will notice the change. In short, the delay you are seeing is the time required for BASIC to get through the main program loop once. This is why it is so important that the STRIG(n) function be able to remember whether a button has been depressed since the last check.

Also, when you run the program in listing 1, try all possible positions of your joystick, as well as the adjusting slides. Check whether values near 255 can be generated. If you exceed 255, the number shown will not change; BASIC ignores such values. Don't be surprised if the numbers in the x and y directions differ appreciably even when the joystick is centered. The variable resistors in joysticks are not manufactured to particularly close tolerances.

Finally, notice that when the joystick is still, the readings may still vary by 1 or 2. When the joystick is centered, then moved and centered again, the reading may not be quite the same. Because of this slight inaccuracy, programs using the joystick generally don't recognize less than a minimum change in a joystick reading, since a small change could be a random, insignificant occurrence.

CALIBRATION

Now that we know how to get a joystick reading, how is the information applied? After all, the numbers mean nothing without a context.

Calibration must be performed at the start of any program using the joystick. At a minimum, this involves reading the values when the joystick is released, using the center point as a reference. More complicated calibration can involve reading the values in each corner as well.

The program shown in listing 2 calibrates joystick A in the x coordinate by taking a reading for the centered position, and then determining whether the joystick is at the center, or to the left or right of it. The center position is represented by a 50 percent plus or minus zone. As mentioned above, this is because the joystick does not always give the same reading in the centered position; indeed, the reading may vary slightly even if the joystick doesn't move. For example, move the joystick very slowly to the right from the center position and notice how the reading flickers between "center" and "right" until the borderline area is passed.

Since the variable resistors vary considerably even from x to y coordinates in the same joystick, the y coordinate of the joystick would have to be calibrated also for those programs that use the y coordinate, such as a

maze-type game. The *y* calibration could be done with a STICK(1) immediately following the STICK(0); then the user strikes the Enter key only once. A second joystick, if present, must also be calibrated; never assume that values that work for one

second joystick, if one is present, would have to be calibrated in addition; never assume that values that work for one joystick will work for another.

joystick will work for another.

The way that the program in listing 2 uses the joystick is typical of game applications in which only the general location of the joystick is of interest. This ignores most of the information available from the Game

Adapter. That is, if there are about 40,000 coordinate pair values possible with the joystick (0 to 200 in each direction), then a game program is losing considerable information by lumping all these values into only the basic five directions. The plotting and drawing programs, which are discussed in the second part of this article, often make use of the location of the joystick in more detail.

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LISTING 1 CONTINUOUS MONITOR OF GAME ADAPTER

```
10 REM This program continually displays the
20 REM state of all the inputs on the
30 REM Game Adapter Card.
40 REM
50 CLS: KEY OFF
                                 'Clear the screen
60 LOCATE 6,9:PRINT "Joysticks
                                             Buttons"
70 STRIG ON 'enable the strig(n) statement
                                'Stick(0) must be read first in BASIC
80 JAX=STICK(0)
90 JAY=STICK(1):JBX=STICK(2):JBY=STICK(3) 'get other readings
100 BA1=STRIG(0):BA2=STRIG(4):BB1=STRIG(2):BB2=STRIG(6)
110 LOCATE 8,9:PRINT "AX ";:PRINT USING "####";JAX
120 LOCATE 10,9:PRINT "AY ";:PRINT USING "####";JAY
130 LOCATE 12,9:PRINT "BX ";:PRINT USING "####";JBX
140 LOCATE 14,9:PRINT "BY ";:PRINT USING "####";JBY
150 LOCATE 8,23:PRINT "A1 ";:IF BA1=-1 THEN PRINT "DOWN" ELSE PRINT "UP "
160 LOCATE 10,23:PRINT "A2 ";:IF BA2=-1 THEN PRINT "DOWN" ELSE PRINT "UP "
170 LOCATE 12,23:PRINT "B1 ";:IF BB1=-1 THEN PRINT "DOWN" ELSE PRINT "UP
180 LOCATE 14,23:PRINT "B2 ";:IF BB2=-1 THEN PRINT "DOWN" ELSE PRINT "UP
190 IF INKEY$="" GOTO 80 'Repeat unless a key has been pressed
```

LISTING 2 CALIBRATION OF A JOY-STICK

```
100 REM This program demonstrates the calibration of a joystick
110 REM so that any manufacturer's joystick can be used.
120 CLS: KEY OFF
130 REM Take readings until a key is pressed
140 PRINT "Center your joystick and press any key
150 JAX%=STICK(0):IF INKEY$="" GOTO 150
160 REM Calculate border lines
170 LOW%=JAX%-JAX%\2:HIGH%=JAX%+JAX%\2:CLS
180 REM Take reading and prepare to print direction joystick is pointing
190 JAX%=STICK(0):LOCATE 10.30
200 REM Print the direction
210 IF JAX% < LOW% THEN PRINT
220 IF JAX%>=LOW% AND JAX%<=HIGH% THEN PRINT " Center
230 IF JAX%>HIGH% THEN PRINT
                                                             Right"
240 REM If no key has been pressed take another reading 250 IF INKEY$="" THEN 190
260 END
```

IBM Diagnostic Tricks

What IBM didn't tell you about the Diagnostic Aids



ARTHUR A. GLECKLER

Along with power-on diagnostics built into the PC and XT, IBM includes a Diagnostic Aids package in the *Guide to Operations* supplied with each computer. The documentation for this package is written with the first-time user of the computer in mind, and leaves nothing to the imagination. Every step in the process of finding the cause of trouble is explained in painful detail, from how to

he Diagnostics program can be started by typing COM-MAND.COM from DOS (with the Diagnostics diskette inserted in the default drive).

insert a disk into the drive and turn the computer on, to where the EN-TER key is. Because the instructions are intended to be understood by the most inexperienced user, IBM has not mentioned several interesting facts about the Diagnostic Aids.

The IBM documentation suggests that the way to get the Diagnostics program running is to insert the Diagnostics disk in drive A and reboot the system. However, it can also be started by typing COMMAND.COM from DOS (with the Diagnostics diskette inserted in the default drive). This causes the Diagnostics command processor to be used, instead of the standard PC-DOS shell. The program will run exactly as if it were booted.

Note that while the Diagnostics program can be run by typing DIAGS from DOS, it will not function properly when told to exit to DOS. It will

return a MEMORY ALLOCATION ERROR and lock the computer up. Nothing short of a power-on reboot will return control of the computer when this happens.

Another interesting, undocumented feature of the Diagnostics program is its ability to run any other program before exiting to DOS. When ready to exit the program, type 99 from the main menu (note that there is no menu line 99, but the function still works). The program will respond with:

ENTER FILENAME TO RUN OR PRESS ENTER TO RETURN TO MAIN MENU

Merely type the name of the program you wish to run, and Diagnostics will load and run it.

The Diagnostics program makes use of a separate program on the Diagnostics diskette to perform this task. It is named CMD99.COM and

nother feature of the Diagnostics program is its ability to run any other program before exiting to DOS.

can be run directly from DOS (although it is not very useful, since the sequence

CMD99 <ENTER>
PROGRAM_NAME <ENTER>

produces exactly the same effect as

PROGRAM NAME <ENTER>

Because IBM does not document this

feature, one wonders what purpose it is designed to serve. Perhaps it is intended as an interface to extensions of the Diagnostics package designed for specific pieces of hardware. For example, if IBM introduces a cold plotter, a PLOTTEST program could be executed directly from the Diagnostics package, eliminating the need to boot the PLOTTEST disk and reload the COMMAND.COM shell.

While neither the COM-MAND.COM start nor the 99 exit are major discoveries in how to use the IBM Diagnostic Aids, they are interesting features in an otherwise uninteresting program.



Susan Glinert-Cole

Two Views of the LANscape

3 Com's EtherSeries and Novell's Sharenet

any organizations, prompted by the desire for more efficient information management, have bought or are considering buying local area networks (LANs). Choosing a LAN can be difficult, because of the complexity of such systems.

A network environment embodies three levels of awareness that present different faces to the outside world. Engineers and hardware support personnel are usually most cognizant of the physical level, and they interact with the system hardware such as network communications boards and cabling. The network administrator, who is involved with user management integrating new application packages into the network, and overseeing the security functions, for the most part, on the network management level. This level encompasses the software necessary to configure, manage, and maintain a sophisticated multi-user operating system with shared-disk access. The enduser interacts, for the most part, with

the third level, the applications link. This level, which encompasses software tools such as compilers, work processors, data base management systems, and electronic mail, relies on the two lower layers to perform physical and managerial functions. The end-user need never be aware of the substrata supporting any application.

All three levels are equally important in a well-designed network. This article looks at the architecture and environment supplied by two sophisticated local area networks (LANs): 3COM's EtherSeries and Novell's Sharenet. Both products are excellent, but they appeal to slightly different audiences.

3COM ETHERSERIES

Ethernet was originally designed for the Alto computer at XEROX, Palo Alto Research Center (PARC). 3COM's implementation of Ethernet is available for three disk servers: the IBM PC/XT, the Altos 586, and the DEC VAX 11750.

Ethernet is comprised of a single coaxial cable that unites individual computers into a straight-line bus network. Multi-branched supernets can be constructed by connecting individual segments together. With careful design, an Ethernet network can accommodate almost any combination of personal computers, fileservers and peripherals. 3COM's minimal system is comprised of three Etherlink cards (one for the disk-server and two for user stations), cabling, system utilities (EtherShare), printserving software (EtherPrint), and software for the electronic mail system (EtherMail).

EtherSeries's implementation of the seven-layer Open Systems Communications Model is as follows. The physical layer consists of the Ethernet transceivers connected to each other by coaxial cable. The transceiver may be internal (as on an Etherlink card) or externally mounted. It can transmit and receive 10 mbits/sec serial bit streams and detect colli-

sions. The cables carry the transmit, receive, and collision detect signals.

At the data-link layer, an Ethernet controller connects the host computer to the transceiver. The CPU bus is not used to transfer information; instead, buffers are set aside that are accessible from both the CPU and the controller (dual ported memory). Data packets (usually called frames) are placed in the buffer memory and the host processor writes the buffer identifier into the controller's transmit-control register. When the line is free of traffic, the controller hardware extracts the data from the buffer, turns it into a bit stream, attaches a cyclic redundancy check (checksum), and an Ethernet header and sends it to the transceiver.

On the receiving computer, the buffer identifier of an available receive-buffer is written into the receive control register by the host processor. When data is sensed, the controller hardware takes each bit from the transceiver, assembles the bit stream into bytes and stores them in the indicated data buffer. The host processor can then read the packets from the buffer memory.

The network layer implements an Internet Protocol (IP), which provides a low-level datagram facility consisting of two procedures: send a datagram (single packet message) and receive a datagram. The address of the intended recipient is embedded in the datagram. The IP attaches

n detect signals. The Tra

transport layer.

The Transmission Control Protocol uses the datagram services of the IP layer to provide reliable connections. The TCP breaks the continuous bit stream received from the presentation layer into packets, attaches a checksum and gives the packet to the IP layer.

The presentation layer consists of the commands that will read and write files to and from the central file-server. It provides the facilities to link and unlink volumes to virtual drives, erase and rename files, create, and delete volumes and give attributes (private, public) to volumes.

The highest layer of EtherSeries, the application layer, consists of EtherMail and EtherPrint. Both these applications use the EtherShare facilities to transfer files and messages to the appropriate printer or recipient.

HARDWARE

EtherShare uses, as a dedicated disk-server, an IBM PC XT or an IBM PC equipped with a fixed disk and at least 256K of memory. Once the server is installed and running, it is dedicated and cannot be used as a work-

station. Multiple servers can be linked into EtherSeries; an XT-based server can handle up to eight users.

Each node in the network must be equipped with an Etherlink board and must be properly cabled into the system (see Churchill, "Etherseries," *PC Tech Journal*, Vol. 1, No. 3: 86-106). The card cannot be installed in an IBM expansion chassis because of problems associated with signal transmission across the expansion cable. IBM inserts a wait state for options in the expansion chassis; this slows the

signal down below the tolerance of 3COM's interface board.

EtherSeries needs one interrupt and one DMA channel for its own use. The board comes ready to use interrupt 3 and DMA channel 1; if desired, DMA channel 3 and/or interrupt 5 can be used instead. EtherLink cards do not present a problem for standard IBM PC equipment, but third-party hardware may require adjusting the jumpers. Good instructions are provided for doing this. The computers at the TECH JOURNAL are equipped with multi-function boards with two serial ports. The second port uses interrupt 3 (COM2:): this had to be disabled before 3COM could be successfully installed.

EtherSeries has an on-board processor called the "Ethernet" processor, made by Seeq. The ROM contains a six-digit unique address that identifies that port to the other units in the network. A 2K buffer that the 8088 recognizes as a parallel port uses the DMA channel. There is room on board for a ROM that

low a user-PC

without any disk drives to boot the network directly from the disk-server; the software to drive this facility has not yet been released.

Installing the hardware was not difficult; unless jumpers need to be altered, the boards are popped into the PC system units, cables are attached (making certain that a terminator is installed at each end of the network), and the unit is turned on. The unique ROM address creates one minor disadvantage: once the disk-

address and decides how the message should be outed through the network. If the

routed through the network. If the datagram is too large, the IP will break it down into smaller packets; the IP at the receiving end will reassemble the packets in the correct order to form the original datagram. The IP then hands the packets to the data link drivers or to the Transmission Control Protocol (TCP) at the

server software has been installed in the presence of a particular interface card, the software and the hardware must henceforth travel together. This forestalls duplication of disk-server software; if another server is required, additional server software must be purchased from 3COM.

an IBM PC with 320K of memory, two floppy disk drives, an IBM graphics printer, and an Apparat 10 MB hard disk. One user-PC was equipped with 512K memory, two floppies, an Epson RX-80, and an expansion chassis with a 10 MB fixed disk; the second user-PC had 320K memory and an IBM graphics printer.

SOFTWARE

The 3COM

The central file-server used was

disk-server runs its multi-tasking operating system as a device driver, and all software used with this network must employ standard DOS device drivers. The EtherShare software allows other PC's to share the server's fixed disk. The server software consists of two modules: administrative and network control. The network control software manages user requests for the fixed disk and printers. The administration module provides the facilities needed to install, configure, and maintain the network environment.

Ample software and excellent documentation is provided with the 3COM system to service both the administrator 2 and the end-user of the

net-

work.

A different set of programs is provided for each of the two operating systems supported by this network: PC DOS 1.1 or PC DOS 2.0. The Administrator's guide details installation of the disk-server and system software (EtherShare, EtherPrint and EtherMail) and then explains how to add the users and their passwords. The User's Guide explains how to work within EtherSeries to set up and manage file systems, run applications software, and send mail.

After the hardware is in place, the disk-server software is installed on the PC or XT. All of the administration software is menu-driven and self-explanatory. The first menu offers a choice of installa-

tion, mainten-

ance, and shut-down procedures. The installation

menu presents another series of options: registration, password assignment, deregistration of the EtherShare unit, installation of network application programs and additional hard disks, and a catalog of all registered EtherShare units. Once an EtherShare unit is registered and an (optional) password is assigned to that unit. EtherPrint and EtherMail system software is copied to the system disk, and additional hard disks, if present, are installed. Assuming that the installation has proceeded without error, the display shows that the EtherShare unit is operational as a network disk-server.

The installation process is continued at a PC running under the selected version of PC DOS. All user machines in the network must use the same version of DOS, either 1.1 or 2.0. The administrator sets up the network with one or the other version; converting the network to another version of DOS requires that the entire network be reinstalled.

The administrator first logs into

the system using the name of the disk-server and then creates the system volume. This volume, called SYS2, contains all the files on the disk-server that will be shared by the network users and is designated with as large a size as desired. After a volhas been created, it

must be associated with a virtual system drive by "linking" it to a drive designator before the volume can be accessed. The sequence of DOS commands

ES LOGIN SERVER1 ES CREATE SYS2 /500K ES LINK D: SYS2

EtherSeries user software is then copied to the system volume and SYS2 is given a PUBLIC attribute so that all users may access it. The final step is adding users with an administrative system utility called UCREATE.

The concept of virtual volumes is central to EtherSeries. Virtual volumes are analogous to a diskette: both contain user files that can be read from and written to. Access to diskette files begins by putting the disk into a drive. Etherseries's analog to this process is accessing a volume by "linking" it to a drive specifier. Once the link has been established, reference to the drive is also a reference to the volume. Although the number of volumes is theoretically unlimited, only four drive specifiers (C:, D:, E:, and F: for floppy-based systems,

D: through G: if a hard disk is present) are permitted. Hierarchical file structure is supported on EtherSeries volumes as they are on diskettes with MS-DOS 2.0. While a diskette has a fixed capacity, a volume can be made any size from 64 kilobytes to 32

megabytes. SYS2, the system volume described above, can thus be likened to a single user DOS diskette and volumes created by users are the diskettes containing working files such as data bases and sales figures. Ample software is provided to manage volumes, erase, copy, rename files, and obtain directory listings.

All users can create volumes using system utilities. Once created, the volume is assigned a name, an optional password, and an access type. When a volume is first created, its default access type is private; only the creator may read from or write to this volume. Public volumes have shared read-only privileges so that many users may be linked to them simultaneously, but only the owner is permitted to write to a volume. The administrator, by the way, is considered the owner of the system volume. This prevents all other users from writing anything there.

If a volume is assigned a shared attribute, then multiple users can both read from and write to this volume at the same time. This can create very serious problems because a shared volume can be updated simultaneously by two users, creating havoc in the file. EtherSeries uses a primitive, user-implemented system of semaphore for protecting shared volumes against multiple-user writes.

Before a shared volume is accessed, the user issues a LOCK command. The disk-server notes that this volume has been locked, and another user who tries to access the file (also by issuing a LOCK command) will be informed that it is in use. When the first user is finished, it is his or her responsibility to make sure that an UNLOCK command is given, otherwise the file will remain in the locked state indefinitely. The problem with LOCK is that the second user can still successfully open the file by simply omitting the LOCK command. Thus LOCK doesn't provide any real protection: all it does is cause the disk-server to enter the locked file name into a table. Should

another attempt be made to lock the same file, a check of the table would reveal the file's locked condition. The burden is therefore on the user to protect against simultaneous file access. Although batch files can be built that provide the necessary security automatically, bypassing the batch file by accident or by intent can have disastrous results. There are more effective ways of handling this situation, as we will see with the Sharenet system.

Network security is based on volume ownership only. A private volume cannot be accessed by anyone other than the owner. Specific files on a volume cannot be singled out for shared or public access; the smallest

therPrint is very
easy to use, and contains a built-in HELP
command that provides information about the EtherPrint command choices.
Like the rest of 3COM's
software, EtherPrint is welldesigned and has excellent
documentation.

unit of protection is the volume.

The EtherPrint applications module lets any user-PC send files or program output to a printer connected to any network server. The server queues the user request and prints the files on a first-come-first-serve basis. Up to two printers can be connected to a print server, and the user can choose which printer to use.

To use a printer attached to a disk-server, the requesting computer must first link a printer to the PC. When a user is finished with print requests, the remote printer should be unlinked from the host; this allows print requests to be directed back to the user's local printer.

Documents are printed with a

header page; the owner of the document and the date are printed in extra-large type on this page. This is a very important and useful feature because it helps to identify the ownership of printed material and provides an easily spotted logical break in what otherwise might be a long continuous printout. Normally, when a print request is received, it is placed in the queue by the server, and documents are printed in this order. The user can instead specify that all of his or her documents be printed at the same time by appending a /HOLD parameter after the print request. Requests from that user are then queued separately, and the user's documents will be printed only after the server has received an UNLINK command from the host, signifying that the user is finished. If a user makes two print requests within 30 seconds or if the queue is otherwise empty, both documents will be printed after a single header page.

EtherPrint is very easy to use and contains a built-in HELP command that provides information, on several levels, about the EtherPrint command choices. Like the rest of 3COM's software, EtherPrint is well designed and has excellent documentation.

3COM's electronic mail system, EtherMail, is menu-driven and incorporates a nice full-screen editor for entering and saving text messages. It provides an intelligent help key and commands to delete words, delete lines, move to the end of the line, move and copy blocks, and fill paragraphs. While not an editor for long documents, it is good for composing short messages and reminders. Data. text, and program files can also be attached and sent along with the message. The mail editor automatically provides a message header of the form

FROM: TO: CC: SUBJ: ATTACH:

The From: field is already filled in

with the sender's name; the To: field must be completed but all the other fields are optional. The cc: field is used to specify another station that is to receive a "carbon copy" of the message. The sender can request that other files (program, data, or text) be sent along with the message by listing them in the Attach: field.

Once the header is filled in, the message can be entered underneath.

Messages can be sent immediately or saved in the "mail folder" for dispatching at a later time. Once sent, the message cannot be recalled from the recipient's in box, even if the message has not yet been "opened."

EtherMail also provides facilities for creating distribution lists, which are useful for sending messages to groups of people. The distribution list may not have the same name as any user in the system.

Messages are listed in the recipient's mailbox by an assigned number, date, sender, and subject (specified by the sender in the Subj. field of the message). If the message has attachments, they are listed under the message with the message number followed by a letter (e.g., message number is 22, the attachment number could be 22A). The FILE command in the editor or DOS's copy command can be used to file the attachment (22A.MSG) on the volume under another name.

SHARENET X

Sharenet comes in two configurations: the Star and Sharenet X. The Star can network up to 24 users with a 68000-based file-server over a total linear length of 6000 feet. The Star server can manage 300 MB of disk space and five shared printers.

Sharenet X uses an IBM XT (or PC with an expansion chassis/fixed disk) as the file-server. Up to three printers, one parallel and two serial, can be attached to the file-server which can manage a total of 320 megabytes of shared disk space.

This network can support a total trunk line length of 4000 feet with

RG-59 or 7000 feet with RG-11 coaxial cable. The thinner RG-59 may be mixed with the less flexible RG-11. Up to 255 physical users (of which only 24-50 users are presently supported in software) can participate in a Sharenet X system. The data transfer rate within Sharenet X is 1.43 megabits per second.

Unlike EtherSeries, which allows multiple servers in a single network and can support a supernetwork architecture. Sharenet permits only a single shared-PC per network (see figure 1). Multiple Sharenet X networks cannot be interconnected. While EtherSeries allows a complex physical layout but implements a relatively simple file security system, Sharenet's designers took the opposite approach: the network is restricted (at the present time) to one centrally shared computer but incorporates an elaborate and elegant file security system that includes a transparent and effective file-locking mechanism.

A system based on a disk server, like EtherSeries, presents a virtual image of the legal volumes a user can access, ensures that the proper type of volume is mounted, and maps volumes to drives. However, it does no file service itself. The work station (and thus DOS) does the actual volume, FAT, and directory handling, in effect, network users must follow stringent rules to prevent multiple nodes from accessing a shared read/ write file at the same time. These rules must be established by the network administrator and adhered to by all system users. As previously mentioned, serious problems might arise if a user ignores these rules.

FIGURE 1: ETHERSERIES OS1 MODEL

OSI Model application layer

presentation layer session layer transport layer

network layer data link layer physical layer EtherSeries Architecture
EtherMail, EtherPrint
protocols
file and terminal (EtherShare)
none
transmission control
protocol
Internet protocol
Ethernet controller
Ethernet tranceiver and cable

By contrast, Sharenet's user stations do no file handling at all. All security and file services, including effective file locking, are provided by

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a file-server and are transparent to the user. The file-server ensures that precautions are taken to prevent simultaneous writes to an open file.

HARDWARE

The Sharenet X system (hereafter referred to as Sharenet) requires at least 256K of memory in the file-server. Sharenet communicates directly with the fixed disk drive controller, bypassing all ROM-BIOS fixed disk function calls. This has an inconvenient side effect: Sharenet must use an IBM fixed disk. Because the IBM controller is proprietary, other hard disks claiming IBM DOS 2.0 compatibility do not work with Sharenet.

The interface card, called a network interface module (NIM), supports a 6MHz Z80B microprocessor and 64K of RAM. Sharenet uses no DMA channels or hardware interrupts. Instead, the 64K on the NIM becomes addressable by the 8088 and is used as dual-ported memory for packet transmission and for holding the CSMA/CD software. As in Ether-Series, a special boot program (not yet available) will allow a PC user-station with no floppy disk drives to boot directly from the file-server. The physical, data link, network and transport layers are all implemented in the NIM hardware and provide a complete point-to-point packeting and transmission subsystem all on one board. Sharenet can send a packet directly to another station; this is called a pipe. EtherSeries, however, routes all communications between user stations through the disk-server.

The physical layer uses Ethernet cable and the Z80B running a CSMA/CD protocol; the data link layer uses the HDLC bit stuffing protocol for frame creation. Protocols for the network and transport layers are proprietary to Novell.

Installation of a NIM into each node is accomplished by setting the memory switches of each card to a unique address and then plugging the card into an expansion slot. A key card, registered to the serial-numbered release of the Sharenet operating system, must also be installed in the file-server unit. The key-card concept is Sharenet's protection against the use of their software packages on unauthorized networks; the concept, unfortunately, requires an additional slot in the PC.

SOFTWARE

Sharenet installs its own multithreaded operating system, called Netware, on the file-server XT. Netware was originally developed in C and assembly language for a 68000based machine and has been ported to the 8088. Novell claims that Netware can be used with any network communications card, such as EtherSeries, if the appropriate driver is incorporated into the operating system. When the file server is turned on. the software initializes the network interface module, loads the CSMA/ CD software into the RAM of the interface card, and performs several functions designed to maximize the speed with which the file server can attend to user requests.

By comparison to the theoretical transmission speeds over network cables, file access can be very slow. A great part of the delay is the time involved in searching directories; IBM DOS does this sequentially and it becomes more time consuming as the size and complexity of a directory increases. Sharenet accelerates disk ac-

harenet can send a packet directly to another station; this is called a pipe. EtherSeries, on the other hand, routes all communications between user stations through the disk-server.

cess in several ways. First, the directory is coded into a hash table (hashed) and this table is then cached into the RAM of the file server. More speed in disk access is obtained by dynamically cacheing blocks of the disk. During each disk access, certain areas around the specifically requested block are cached according to an algorithm that optimizes the next access. All disk writes are cached as well, so writing is done to a buffer, and the physical task of writing to the hard disk is done in the background. Realizing that the slowest parts of disk access are the seek times, Sharenet designers use an "elevator" seek method. The operating system takes a queue of seeks, sorts them into order. and caches the list. Disk I/O is performed relative to the current position of the disk head and not on a first-come-first-serve basis.

Unlike 3COM's EtherSeries, Sharenet does not modify PC-DOS. Instead, when Sharenet is booted on a user station, a shell is built around the host operating system. Novell can supply shells for virtually any operating system. The file-server stores information on the shared disk in its own format and is therefore indifferent to the shell's native type. This means that different computers and/ or operating systems may all be connected to the file-server. When it is loaded, the shell lets the file-server know what operating system it is dealing with, so the proper translations can be made. The shell takes care of formatting the information for the operating system.

The shell takes up 8K of memory when used with DOS 1.1 and 12K with DOS 2.0. It loads just above DOS and remains resident. The shell's function in PC-DOS is to trap interrupt 21, the DOS service call. For disk requests, if the call is for a local drive, Sharenet hands the request to PC-DOS to be processed in the usual manner. If the call is for the shared disk, the interrupt is fielded, packeted, and transmitted by the shell to the remove file-server. The shell adds six to ten instructions of overhead on every interrupt 21. Sharenet also extends DOS service with about 30 function calls on interrupt 21 - calls that handle network facilities like print spooling and record and file locking.

Sharenet will support user stations running PC-DOS 1.1 and PC-DOS 2.0 simultaneously. Sharenet's shell provides the user with a file structure appropriate to the operating environment used. EtherSeries, by contrast, can support either version, but all nodes, including the server, must use the same version of DOS.

Sharenet's operating system performs all field manipulations and tracks all user access as set up by the administrator. Installation of the fileserver is done very simply by running the provided INSTALL program. Like all of Sharenet's software, the program is self-explanatory and easy to use. Certain decisions have to be made at installation time concerning the number of directory entries permitted on the system, the number of volumes to be created on the hard disk and whether the directory is to be cached in memory at all times. Sharenet also offers the option of hashing the directory to minimize search time. These options are specified at installation, but can be changed after the initial setup.

The installation program offers detailed explanations and suggested settings for each option. The options available are

1. The number of cylinders

on the fixed disk to be allocated to Sharenet (minimum of 50). If the file server is to be dedicated to Sharenet, then the entire fixed disk can be allocated to the network. MS-DOS programs can be run on the XT if a partition is defined for it at installation time and is activated with the IBM FDISK utility. Sharenet allocates track zero on the fixed disk for itself. This makes the file-server unit self-booting but creates an interesting problem when and if the file-server is converted back to a plain vanilla computer at a later date. Novell supplies a utility that will reformat the fixed disk so that it is usable with MS-DOS.

- 2. The number of open files allowed in the network at once. Each open file requires about 40 bytes of memory on the server PC. Too many open files may result in an out-of-memory error; too few files will unduly restrict the users.
- 3. **The cache buffer size.** Larger cache buffers generally improve performance unless the XT is running out of memory because too many open files were specified.
- 4. **Sharenet volumes.** After the system volume has been defined, the administrator can divide the fixed disk into several volumes. Novell recommends only one volume per physical disk to reduce overall system complexity.
- 5. Cacheing the directory.

 Cacheing the directory decreases directory search time and is recommended for at least the system volume directory. If more than one volume has been defined on the fixed disk, memory limitations may prohibit directory cacheing for the other volumes.
- 6. **Hashing the directory.**This is recommended for the system volume. Hashing takes 4 bytes per entry; it is suggested that all directories on the volume be hashed for optimal searching.

Once all the parameters have been properly entered and checked, the system installs itself as a self-loading module and prompts for the disks with the system files, which are then transferred to the fixed disk.

Security is provided on multiple levels: log-in, directory, user, and file. The system administrator sets up access privileges on the log-in and directory levels. Although a user might be able to search a directory, he or she may be denied the ability to read or write files here, as well as at the level below this one. The supervisor has automatic access to the volume SYS:SUPER, which contains the programs used to set up user entry into the network and to change

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system parameters, such as public volume attributes.

Access to the supervisory functions is through the menu-driven program PASSWORD.EXE. When this program is first invoked, a supervisor password must be defined; subsequent access to the administrator menu is allowed only after entering this password. PASSWORD.EXE presents a menu with eight functions: add a user, delete a user, examine a specific user, list all users, examine a directory, create a directory, list a directory and exit program.

To create a user, choose function 2; a second menu appears for editing user rights and privileges. These include entering a new user name, ad-

TABLE 1: Sharenet Directory Access Privileges

Access Level Access Type ability to read files Read ability to write files Open ability to open files Create ability to create files Delete ability to delete files Personal Ownership user has ownership rights to directory Search Directory user can view the directory Modify flag status ability to modify the status of files (i.e. shareable or

ding/editing the user's log-in password, defining a user's public search path or access to system volumes, adding/changing a user's home directory, and changing a user's path rights (access to directories other than system or home directories).

read/write

A user need not be a single entity; provision is made for adding groups of sentient beings with identical privileges using the GROUP.EXE utility. This program is used mainly to set up user groups for electronic mail and is similar in concept to 3COM's distribution list.

Security in Sharenet is provided by a combination of access privileges on several levels: directory, user/ group and file. When a directory is created with the PASSWORD.EXE program, it is given a "privilege mask" constructed from eight options, as shown in table 1.

A user/group may be designated as a personal owner of the directory, in which case all privileges associated with the directory are available to that user, or the user/group may be granted trustee status. A trustee has only some rights to the directory. All owners are trustees of a directory, but the reverse is not necessarily true. For example, let's say the supervisor creates a directory called SYS:SALES and assigns a mask to it that consists of all privileges except DELETE. User Fred is then created and assigned ownership rights to SYS:SALES. The directory mask is ANDed with Fred's privilege mask; Fred can read, write, create subdirectories, open files assign personal ownership to subdirectories, and change

the attribute of a file in the directory (private, public, shared, read-only) but even Fred cannot delete information from SYS:SALES.

If the personal ownership flag is not granted at the directory level, then no one can "own" this directory; hence no one can make subdirectories within it. Directory privileges take priority over user/group privileges, and a directory can have an unlimited number of trustees.

In general, the supervisor grants all directory rights in the PASS-WORD.EXE program and assigns owners by granting the user ownership rights to only one volume per physical disk to reduce overall system complexity and to avoid administrative problems.

Sharenet then points that drive to the user's home directory (as specified by the supervisor) or to a drive that the user has specified by a script file created with the SYSLOGIN utility (see below). Sharenet also points logical drive Z: to the system directory (SYS:PUBLIC), which contains all network utilities and any other files the supervisor has placed there.

Sharenet comes with many utilities for managing directories. The Sharenet DIR command is similar to PC-DOS in that when invoked, it will display all the files contained in the specified directory. ERASEDIR

harenet has many utilities for managing directories. The Sharenet DIR command is similar to PC-DOS in that when invoked, it will display all the files contained in the specified directory.

removes an empty directory, LIST-DIR lists subdirectories beneath a specified path, HIDEFILE marks a file as hidden, MAKEDIR creates a directory and so on. An important fa-

cility is the command NPATH, which, like DOS's PATH command, lets a user establish a prioritized list of volumes to be searched for files. Unlike the DOS 2.0 PATH command, however, Sharenet's NPATH is an integral part of the file system and therefore works for data filenames as well as program filenames.

Remote print facilities are incorporated into Sharenet (EtherSeries splits these functions out into Ether-Print). There are two ways to select print spooling to a remote printer: SPOOL and NPRINT. SPOOL is used when the file to be printed doesn't yet exist or a printed form is being created by a word processor. When the first SPOOL command reroutes the local printer output to a temporary "bucket," that remains open until a second SPOOL command, an NPRINT or an ENDSPOOL command has been received. When the bucket is closed, all the files contained therein are queued at the remote printer and are printed as one file named LST. The SPOOL command can be followed with a plethora of arguments: tab settings, copies, printer number, form number (if the print job is a form that needs to be mounted), banner name, cancel commands for banner, and tabs. NPRINT <filename.ext> queues a single existing file to the shared printer and also can have a lengthy train of parameters following after it.

SETLOGIN is a text editor used for creating a start-up text file à la PC-DOS's AUTOEXEC.BAT. Initial drive assignments and messages can be designated in a file that is automatically read and executed by Sharenet each time the user logs in.

Sharenet's electronic mail system (EMS) is not menu-driven and isn't as friendly and convenient as 3COM's. EMS is command line oriented, and while it does have a nice (although incomplete at review time) HELP facility, the user is still forced to remember the sometimesconfusing command syntax. EMS is an integral part of the network and

provides each user with a secure mailbox. When the network is installed, a subdirectory SYS:MAIL is created; in it is a unique subdirectory for each user in the system. These mailboxes can each contain up to 127

o conserve system security, users may not directly access another person's mailbox.

When a message is sent via EMS, it doesn't go directly to another mailbox. Instead, it goes into a temporary file. When a recipient logs into the mail system, the file is copied into the user's mailbox, to be read, put into another subdirectory, or sent to another host.

items. The owner of the mailbox is the trustee of that subdirectory and is granted all privileges.

To conserve system security, users may not directly access another person's mailbox. Sharenet gives all users only the CREATE and WRITE privileges to the subdirectory SYS:MAIL (users may not OPEN or READ files there). When a message is sent via EMS, it doesn't go directly to another mailbox. Instead, it goes into a temporary file. When a recipient logs into the mail system, the temporary file is copied into the user's mailbox where it can be read, put into another subdirectory, or sent to another host (forwarded).

There are four arbitrary categories of mail: memos, letters, documents, and files (such as program and data), and all references to a communication must bear a category label. So, for example, if a memo is to be composed with the editor, the sender enters the command

EDIT MEMO TOMATOES

An editor screen appears with the memo title above the text entry display; the sender then types in the body of the message and saves the message by pressing F2. The item can be mailed in the "normal" way, or by "express." In the normal mode, the message is transmitted to the recipient, who will know it has arrived only when he or she checks the mailbox. If a message is sent express and the user is on-line, he or she is informed by a beep and a prompt of its arrival. The user can then check the mailbox at leisure to read it.

EMS contains a small query/data base system that enables users to enter English-like commands such as

read all memos from secret admirer list archived mail from anyone in research trash all letters from the boss

Group attributes can be ANDed with one another. If an accounting group and a secretary group have been defined by the supervisor, mail can be sent to all secretaries in the accounting department—a pleasant alternative to manually listing all recipients.

There are several nice touches in the Sharenet utility package. NTEST is a facility designed as a teaching tool for programmers who wish to experiment with the function calls available on the network. It is entirely menu driven and lets the user experiment with the network disk I/O at the level of the extended DOS function calls. A multi-user game called SNIPES is also provided. It's sort of a maze-cum-arcade affair, quite engaging, and quietly underscores Sharenet's underlying performance capabilities.

NETWORK PERFORMANCE

We tested the performance characteristics of these two networks with regard to I/O efficiency in several ways. The following files were generated: a random access file of 50 records, each record *** long, a se-

TABLE 2: EtherSeries/Sharenet Benchmarks

PC*DOS 2.0	Random Access	Sequential Read/Write	Sequential Read	dBase Sort 1 Key	dBase Index 1 Key
Apparat Hard Disk IBM Hard Disk	0.06 0.06	0:31 0:29	0:14 0:14	0:40 0:40	0:26 0:29
EtherSeries Single user (Apparat Hard Disk)	0:16	1:06	0:15	0:45	0:36
EtherSeries 2 users (Apparat Hard Disk)	0:30	1:54	0:19	e <u>nd</u> er de les ormes de la comp ormes de la company	i <u>A</u> nterilac Seat religi Bull-18-18-
Sharenet Single User (IBM Fixed Disk)	0:09	0:32	0:17	0:43	0:29
Sharenet 2 users (IBM Fixed Disk)	0:07	0:36	0:18	0:46	0:32

TABLE 3: Word Processor Benchmarks

		Single User	Novell	Novell 2 Users		
Word Perfect (ver. 2.3)	AC-DOS 2.0	Etherseries	Single User	User 1	User 2	
Load WP from hard disk	0:04	0:06	0:09	0:10	0:10	
Exit WP	0:01	0:01	0:02	0:02	0:02	
load file from floppy disk	0:06	0:03	0:05	0:05	0:05	
save file to floppy disk	0:26	0:18	0:18	0:23	0:20	
load file from hard disk	0:02	0:02	0:03	0:06	0:05	
save file to hard disk	0:15	0:15	0:15	0:20	0:15	
Word Star (ver. 3.3)						
load WS from hard disk	0:06	0:06	0:08	0:08	0:09	
exit WS	instant	0:01	instant	instant	instant	
load file from floppy disk	0:03	0:03	0:03	0:05	0:04	
save file to floppy disk	0:32	0:31	0:31	0:34	0:33	
load file from hard disk	0:03	0:04	0:03	0:06	0:06	
save file to hard disk	0:10	0:12	0:13	0:16	0:17	

quential file of 651 lines of random length, and a dBASE II file of 200 records and six fields (name, number, street, city, zip and phone). For the RANDOM test, 50 records were randomly read and written within the file. The SEQUENTIAL READ test read the 641 lines and the SEQUENTIAL READ/WRITE test read a line and wrote it to another file. Two other tests were done with the dBASE II file: sort 200 records into another file and index the 200 record file, both by a single key.

We also tested the time it took for two word processors—WordPerfect version 2.3 and WordStar version 3.3—to load themselves, load a 30,000 byte file to and from fixed and floppy disks, and exit back to the system. The tests were run with MS-DOS as a baseline, one user station booted under network software, but no network running (single-user station); two user stations networked to the shared disk ran the tests simultaneously. Because of the very

B oth networks performed excellently in day-to-day operation. The software is easy to use and has a command syntax compatible with PC-DOS. Neither network is difficult to install or maintain; all parameters can be quickly changed.

short time we were provided with 3COM's product, we were unable to perform some of these tests with EtherSeries. The results of the tests are presented in tables 2 and 3.

There was no dramatic difference between Sharenet, running as a single user station, and DOS 2.0 on any of the tests performed. 3COM's EtherSeries did suffer some performance degradation with the RAN-DOM and SEQUENTIAL read/write

tests on a single user station: it took about twice as long for these tests compared to the baseline. With the dBASE II tests, 3COM ran about 22 percent slower, and Sharenet about 9 percent slower, than PC-DOS overall.

Interestingly enough, Ethernet ran faster than PC-DOS on some of the word processor benchmarks. Sharenet was about even, but in general, word processor performance did not suffer significant degradation.

Both networks performed excellently in day-to-day operation. The software is very easy to use and has a command syntax compatible with PC-DOS. Neither network is difficult to install or maintain; all parameters can be quickly changed with the administration utilities. EtherSeries has the advantage that many server units can co-exist over the network, allowing an office to establish dedicated servers for different uses (sales, production and so forth). However, EtherSeries offers no file and record locking and unless an application program is equipped to handle it, serious problems could arise. A third party vendor, Visicorp, is now offering VisiCalc IV and VisiWord as application programs for the EtherSeries; this is a step in the right direction. In order to guarantee protection, however, network users should use only those application programs with these features built in: off-the-shelf software must be used cautiously with the cumbersome LOCK and UNLOCK commands.

Sharenet is a very powerful, sophisticated and beautifully implemented network. It provides that nemesis of the local area network—true file and record locking—in a manner that is completely transparent to the user. The software is excellent: well designed, easy to use and more than ample to serve the user and the administrator. Sharenet's file security scheme is complex but goes miles beyond most other networks we have examined. With EtherSeries, the smallest unit of protection is an entire volume. A user cannot assign an

he choice between these two products depends on which factor is more important to the office situation: having multiple servers, or effective security and file/record locking. Either choice will provide a first-class view of the LANscape.

attribute to a single file. Sharenet provides eight privileges to directories, eight to users and four attributes to files. Novell will also be offering application packages that are designed to run in a true multi-user situation—compilers, data-base managers and the like.

The pricing for these two networks is comparable. A Sharenet X starter system, including all hardware, software, documentation and cables for the file-server and two user stations, is \$2900. Each additional user station is \$695 for hardware and software. A comparable starter system for EtherSeries is \$3375.

The choice between these two products depends on which factor is more important to the office situation: having multiple servers, or effective security and file/record locking. Either choice will provide a first-class view of the LANscape.

ISO-OSI Model

Several years ago the International Standards Organization (ISO) developed a reference system for network operation called the Open Systems Interconnection (OSI) model. The architectural framework, and the operation principles incorporated therein, is used as a basis for the design and implementation of networks.

The accompanying figure illustrates how the seven-layer ISO-OSI model connects two computers in a network environment. Each protocol layer can be thought of as a process that communicates with the corresponding process in another comput-

An Overview of the ISO OSI Protocol (International Standards Organization Open Systems Interconnection Model)

7. application layer application
6. presentation layer presentation
5. session layer session
4. transport layer transport
3. network layer network
2. data link layer data link

1. physical layer

physical

er. A process can be embedded in the network hardware (the RS-232 standard, for example), or it can be implemented as a software package (such as electronic mail). The interaction of the corresponding layers of two hosts is called *peer protocol*. In reality, however, physical communication only takes place at level 1; this is where the system hardware is located.

Communication is effected between a sending and receiving computer in a vertical fashion. A message is framed at level x, transmitted down each layer of the sending computer until layer 1 is reached, sent over the physical link, and passed upward to the corresponding layer x in the receiving unit.

Interaction between two layers in the same host is called *an interface*. Each layer is functionally independent of any other layer. Layers are unaware of the header formats or protocols used by other layers and interact with each other exclusively through their mutual interface.

The OSI model is often divided conceptually into two subnets. Layers 1 through 3 are always standardized according to the OSI protocols and are concerned with routing data from host to host around the network. Layer 4 provides a transparent interface to layers 5–7, which use the communication services supplied by the lower level protocols. The upper layers are usually proprietary to the network vendor and rarely follow standard procedures.

The application layer is the interface between the end user and the remainder of the network protocols. The highest level of software—compilers, data base managers and mail facilities—operate here. When an application program receives a request from the user, it transmits it to the presentation layer. This layer takes care of any file-handling that might have been requested from the application program. It may also be called upon to do text compression and perform any conversions that might be required. The information is then passed to the session layer, if present

The session layer is responsible for establishing, managing and dismantling connections using the host-to-host service provided by the transport layer. Two important functions are implemented here: remote logon activities and a safety feature for centralized files called bracketing. If a shared file is opened for updating, the session layer protocol notes the open bracket and forestalls an actual file update until a closing bracket appears. Thus, if the network, or the transmitting host, should crash before the closing bracket is received, no damage will occur to the file. Session layers do not exist in many networks; these services are then assumed by the transport and presentation layers.

The transport layer shields the customer's portion of the network (5–7) from the carrier's portion (1–3), it also hides all the details of the communications subnet from the session layer so that one type of subnet can be replaced by another.

The lower layers do not ensure that the bit stream sent by the source will arrive intact; information can be lost or shuffled due to malfunctioning hardware or software. The transport layer provides a reliable host-to-host protocol for use by the session layer. The data stream may be broken up into packets called datagrams for use by the low-level subnet. Because each packet is an independent entity, a checksum and destination address is attached to each one; they are then handed to the network layer for further processing.

The network layer provides a service for delivering from the source computer to the destination and determines what path a packet of information will take through the network. In most local networks, this layer contains facilities for low level datagram processing such as Send/Receive Packet. After attaching a source address to the datagram and deciding the route, the packet is given to the data link drivers.

In some networks, the data link layer converts a raw bit stream received from the physical layer into separate frames. Common protocols are HDLC (high level

data link control) and SDLC (Synchronous data link control). They use a process called bit stuffing to partition the data into frames delimited from each other by a particular bit pattern. Almost all data link protocols attach a checksum to the frame header or trailer to detect, but not correct. transmission errors. When a frame arrives at a destination, the embedded checksum is compared with a locally generated one. If there is a discrepancy, the data link layer knows that an error has occurred during transmission and passes this information to the appropriate upper level layer for processing. In the other direction, the data link layer removes the data link (frame) header and trailer and passes the remainder to the network layer.

This layer is also responsible for flow control. Not all computer in a network are able to send and receive at the same rate; there must be a way to evenly regulate the flow of data. There are two common protocols used to do this: "stop and wait", and "sliding window". The "stop and wait" method sends a positive acknowledgement signal back to the sender to say that the transmission was successful and more data can now be sent. Sliding window protocols assign a sequence number to each frame and both the sender and receiver keep a running tally of valid sequence numbers. Several frames can thus be sent before an acknowledgement signal is returned.

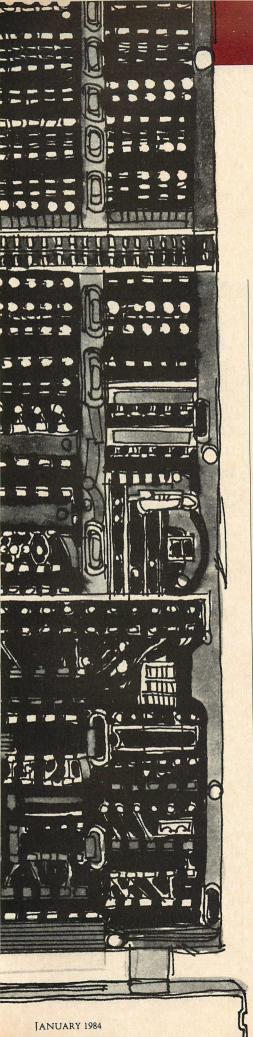
The physical layer is concerned with the transmission of the raw bit stream. It pays attention to such dreary details as how may pins are on the connector, whether the transmission is half or full duplex and how long a bit will last on the line. There is no concern for garbled transmission or what the bits might represent. The best known physical layer is RS-232-C, which details the meaning of each of the 25 pins on the terminal connector and the protocol governing their use.

Most linear or local area networks use a physical protocol called CSMA/CD (Carrier Sense Multiple Access with Collision Detection.) When a station wants to send a message, it "listens" to the cable to see if it is in use. If another station is transmitting, the first station waits before retrying (Carrier Sense). Multiple Access means that all computers share the same coaxial cable. All nodes "hear" all transmitted packets, but pay attention only to those packets that contain the embedded address of that station. All other packets are discarded. Collision Detection deals with the problem of two computers attempting a simultaneous broadcast. When such a collision is detected, both stations retry transmission after a random length of time.

MULTI FUNCTION boards for the DOC

A survey of sixteen boards for those ready to expand





hen IBM introduced the PC in August 1981, one of the first and most widespread criticisms of the machine was that it did not have enough expansion slots. At that time, IBM was the only supplier of expansion boards for the PC, and almost all of its boards supported only a single hardware function. As a result, the PC's five expansion slots were quickly filled, and a system with only a display, disk drives, 128K memory, printer, and modem could not be expanded any further.

This situation did not last long, as foresighted hardware manufacturers saw a ready market for more advanced expansion boards. These manufacturers introduced boards with serial and parallel ports and room for up to 512K memory, giving IBM's 64K, memory-only expansion board tough competition. Subsequently, IBM introduced a 256K memory expansion board. While this board is a significant improvement over the older 64K board, it still does not have the increased functionality and lower price that many independent vendors' boards offer. Rumor has it, however, that IBM is hard at work developing its own multifunction board.

Both the XT and the revised version of the PC can expand memory to 256K on the system board itself. Before the introduction of these machines, IBM's PC could support only 64K on the system board. Independent manufacturers produced 512K memory boards so that users could expand to the maximum of 576K. Now, however, hardware vendors are producing boards socketed for 384K, so that owners of the XT and 256K PCs can expand up to the maximum

of 640K supported by IBM.

The purpose of this review is to provide detailed information on as many boards as possible, so that the potential buyer can make a wise choice. In order to be included here, each board had to have 1) memory which can be used to store programs and data (a board with graphics display memory only, for example, would not qualify, because its memory would not be usable for purposes other than displaying graphics), and 2) at least three hardware functions other than memory.

These criteria did not filter out many boards, as almost every multifunction board on the market today has memory and at least three other functions. On the other hand, it was important to have some way of uniformly sampling boards so prospective buyers could make better comparisons. For example, although IBM's monochrome display and printer adapter could technically be classified as a multifunction board, it would not be helpful to compare it to memory expansion boards.

HIGHLIGHTS OF THE BOARDS

The modular board is an interesting innovation. Owners of these boards can mix and match functions to suit their needs exactly.

Both LNW Computers' BusBoard and Maynard Electronics' SandStar Memory Card offer the ability to attach smaller boards, called *modules*, to the main board to add new functions. The two are similar in concept, but very different in design. The

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Maynard board is designed to accept up to three modules and a piggyback memory board. The modules have a very low profile, and there are few components on the main board under the module connectors. The board was designed in this way so that it would fit into one PC slot without encroaching upon other slots.

In addition to its modular memory board, Maynard offers other modular boards, including a six-module board without memory and a three-module board with a floppy disk controller. Thus, if the SandStar Memory Card does not accommodate enough functions, another board can be purchased for installing extra modules.

LNW Computers' BusBoard was not designed with the goal of fitting into exactly one slot. Even when no modules are mounted on the board, the connector pins, which protrude from the back of the board, add considerably to its width. These pins are used to expand the board beyond the eight standard modules and two coprocessor modules that can plug directly into the board. Unlike the modules on the Maynard Electronics board, the BusBoard modules can be stacked on top of each other. By adding several modules, the BusBoard can become wide enough that it takes over adjacent slots (LNW recommends mounting it in the outside slot in the PC next to the speaker).

Maynard Electronics' SandStar Memory Card has the advantage of simplicity of design and small size, but the LNW BusBoard offers more expansion per PC slot and a much wider selection of modules (although the latter may change, as Maynard introduces more modules).

Profit Systems' marketing strategy is certainly a departure from the norm; while most manufacturers provide free software with their boards, Profit Systems supplies a free board with their software (at least that's what the ad says). Their TascMaster program will allow the PC to run up to nine tasks at the same time. The software divides the PC's memory into several partitions, each of which is used to store a task. The PC with TascMaster acts as several different PC's, each running a separate program, each with its own operating system, and each with its own screen. Any task can be made the current task by pressing the Alt key with a number (0-9) on the numeric keypad. As soon as this is done, the screen of the current task is stored. and the screen saved from the new task is called up.

Note that Profit Systems has been careful to assign key combinations that are not used by others programs. The Alt-9 key combination, for example, works only with the 9 on the numeric keypad. However, if another application program uses the Alt-9 (with the 9 on the numeric keypad) combination, problems could occur. Although Profit Systems has tried to use uncommon key sequences for controlling the TascMaster, the possibility of clashes with other programs still remains.

The TascMaster software lets the user allocate memory to each task, and specify whether only the currently active task is to execute, or all tasks are to execute simultaneously. The TascMaster is excellent software, and comes with excellent documentation. Although a DOS 2.0 version is

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not available at the time of this review, Profit Systems has promised that one will be available soon.

COMMON PROBLEMS

Providing more than one connector has proven to be a formidable problem with multifunction boards: Connectors need to be firmly attached to the PC, but there is only so much room on the mounting brackets. Companies whose boards have both serial and parallel interfaces, for instance, have to find a different place to mount connectors.

The IDE Associates IDEAboard has a 9-pin serial connector and a standard parallel connector on its mounting bracket, and includes a cable to connect the 9-pin plug to a standard serial connector. This is an excellent solution for the IDEAboard, because it does not have any other functions which require connectors.

Several companies have tried to solve the cable-mounting dilemma by putting no connectors on the mounting bracket. Instead, they route cables through openings in the mounting

bracket, where they can be mounted on external mounting brackets. AST Research offers an optional external mounting bracket, called the ConnectAll. STB Systems includes a similar bracket with all its boards as a standard feature. Both brackets are designed to be attached to the power supply mounting screws in the middle of the back of the PC, and are routed in front of the mounting brackets of all boards to their left before reaching the external bracket. Although these brackets are not ideal, they are more than adequate.

The best solution comes from Persyst, which provides its Cliff Hanger external bracket with each cable. The CliffHanger is a metal bracket that encloses the cable's connector. The bracket rests on the upper edge of the back of the PC, between the expansion boards and the PC's metal cabinet, and provides a firm connection for the cables. In addition, none of the cables between the board and the external connectors is ever actually outside of the PC cabinet, which results in less cable clutter behind the PC. With the mounting schemes of AST and STB, on the other hand, these cables are routed outside of the PC, where they connect between the expansion board and the external bracket.

The release of DOS 2.0 has created another problem for multi-function board manufacturers—that of software compatibility. Although print spoolers and clock/calendar software will generally run under both operating systems, electronic disk software often will not. Many manufacturers' electronic disk programs have been rewritten to take ad-

vantage of DOS 2.0's device driver capability. Since software implemented using device drivers will not work under DOS 1.1, multifunction board vendors will often supply two versions of each program.

In general, the software compatibility problem has been addressed well, but users of DOS 2.0 should make sure that the software included with the board they buy matches their version of DOS.

With the advent of the XT and the 256K-system-board PC, the documentation of most multifunction boards has needed updating. At the time of this review, however, many hardware vendors have not updated their documentation to reflect this change. This can lead to confusion, as the user of a 256K-version PC reads documentation written for a 64K system, which explains that if no other memory boards are installed, the new

board's switches need not be changed. The confused user installs the board, only to find that not only does the new memory not work, but that part of the memory already installed on the PC's system board no longer works. This is because the starting address of the board has been set at 64K rather than 256K and part of the memory in the board is "overlapping" the memory on the system board.

Yet another problem has been created by the XT's introduction. In order to fit eight expansion slots into the XT, IBM made each slot slightly thinner than the slots in the PC. As a result, the mounting brackets on boards destined for use in the XT are of a slightly different, slimmer design than the mounting brackets IBM initially used for PC expansion boards. Although the XT mounting bracket works both in the XT and in the PC, many board manufacturers are not

Buying Software on the Side

Some hardware manufacturers will sell the software that is included with their expansion boards separately. Following is a list of some, including prices.

AST Research, Inc.

Print spooler \$45 Electronic disk \$45

IDE Associates

Print spooler \$45 Electronic disk \$45

Indigo Data Systems

Black-and-white screen dump for EPSON printers \$45 Color screen dump for IDS Prism color printer \$50 Print spooler \$45 Electronic disk \$60

Persyst

Print Spooler and electronic disk together \$100

Quadram

Print spooler and electronic

disk together \$20 **Sigma Designs, Inc.**

Print spooler and electronic disk together \$50

STB Systems, Inc.

Print spooler, electronic disk, and special utility software together \$80

Tall Tree Systems

DOS 1.1 JFORMAT (Print spooler, electronic disk, hard disk support, high-capacity drive formatter together) \$60 DOS 2.0 Print spooler \$40 DOS 2.0 Electronic disk \$40 DOS 2.0 Hard disk support \$40 DOS 2.0 High-capacity drive

formatter \$40 Vista Computer Company, Inc.

Print spooler \$30 Electronic disk \$30

And A Few Additional Points

In doing the testing for this review, I encountered some quirks and some good features that helped differentiate the 16 boards. Following is the more subjective and detailed information contained on each multifunction board.

AST RESEARCH (MEGAPLUS AND SIXPAKPLUS)

The documentation for these boards is complete and well-organized, but is too long to be read when installing the board. The manual should include a brief section explaining how to install the board, with the more detailed, technical information in a reference section.

A program to clear all memory in the PC is included.

COMPUTER PERIPHERALS (PCM-PSC)

The documentation supplied with this board is four pages long. It explains the barest minimum on installing the board, and gives no hints as to what to do if not everything goes perfectly. There is no documentation on using the clock/calendar software.

The clock/calendar software, written in BASIC, has not been compiled. The program is not well-commented, so there is little justification for writing it in BASIC, which is inconvenient to use (especially from an autoexec.bat file).

IDE ASSOCIATES (IDEABOARD)

This board includes a SASI hard disk port, but no cable hard disk cable. IDE Associates includes the cable with their hard disk drive, the IDEAdisk.

The memory test software included with this board works very nicely and automatically keeps track of all errors that are encountered.

The IDE Associates board does not come with electronic disk and print spooling software; these programs must be purchased from IDE separately.

INDIGO DATA SYSTEMS (PC MULTIBOARD)

Programs to do black-and white graphics screen dumps on the Epson and IBM Graphics printers, and color graphics screen dumps on the Integral Data Systems Prism color printer are included.

Quick reference cards are included. They cover:

Installation and Configuration Screen Print Software (Color and B/W)

Clock/Drive/Spooler Software

Documentation on disk is included with the board. It is supplied as a text file, and can be sent to the printer easily. A program to move through the documentation a page at a time is included.

LNW COMPUTERS, INC. (BUSBOARD)

The following modules are currently available:

RS232 Serial Port
Parallel Printer Port
Clock/Calendar
Game Adapter
58" Floppy Disk Controller
16 Channel Analog-to-Digital
Converter
8 Bit I/O Port
Prototyping Module
300 Baud Direct-Connect Modem
Z80 Coprocessor

The following modules are under development:

8088 Coprocessor
EPROM Programmer
Speech Synthesizer
D/A Converter
Network Controller
Synchronous Communications
Port
Relay Controller
IEEE488 Interface
BSR X10 Controller
DTMF Decoder

The mounting bracket has one large hole with no built-in connectors, because

the BusBoard itself supports only memory. The hole is large enough that almost any number of cables can be routed through it.

On the component side of the board are four vertical female connectors (for standard modules) and one horizontal female connector (for coprocessor modules). On the opposite side of the board are four corresponding vertical groups of pins (for the standard modules) and one horizontal group (for coprocessor modules). Each module has a similar group of pins on its back (for connecting with the connectors on the component side of the BusBoard) and a female connector on its front (for the pins on the back of the BusBoard). Modules can be stacked.

The clock/calendar software provides a unique alarm function. The program can be set with up to ten alarms to beep at predetermined times, no matter what other program is running in the PC. In addition, the clock/calendar software can be programmed to run a batch file from DOS at a predetermined time.

A complete print spooling package is included with the BusBoard. It can:

Print on up to five printers simultaneously

Print either a queue of files or everything sent to the printer ports

Buffer to disk, memory, or both Send output to a disk file for later printing

The print queue can be edited: files can be added, replaced, inserted, and deleted from the queue, and the printer can be stopped and started.

MAYNARD ELECTRONICS (SANDSTAR SERIES MEMORY CARD)

The following modules are currently available:

RS232 Serial Port Parallel Printer Port Clock/Calendar Game Adapter

The following modules are under development:

Hard Disk Controller (requires three module slots)

Modem (requires two module slots)

SASI Hard Disk Interface (requires two module slots)

There are no DIP switches on the SandStar Memory Card for setting memory start address and total size; the board uses barrels and cable instead. Barrels are small (approx. 1 mm diameter) cylinders protruding upwards from the board. They are designed to accept the ends of jumper wires. Memory is configured by linking the barrel for each 64K memory bank to a barrel that specifies the starting address for that bank. This allows each bank to be independently positioned within the PC's memory address space, allowing for noncontiguous memory configurations, which, according to Maynard Electronics, is an advantage over other, less flexible boards. Despite the benefits, the barrel technique is very inconvenient to use, especially considering that the documentation on this aspect of the board is terrible.

In addition to the SandStar Memory Card, Maynard Electronics offers these modular boards:

SandStar Multifunction Card
This card has no built-in
functions at all; it supplies
six slots for modules

SandStar 5¹/₄" & 8" Floppy Drive Controller Card

This card has a built-in floppy disk controller, and three slots for modules

PERSYST (TIME SPECTRUM)

The print spooler and electronic disk software have help menus that can be called up by appending '/?' to the end of the command program name (typing 'ID/?', for example, will produce a help menu that can be used for the Insta-Drive electronic disk program).

PROFIT SYSTEMS (ADDRAM ELITE)

The TascMaster software, which lets the PC run up to nine tasks simultaneously,

is included (see text for more details). Note that the TascMaster program will not work on systems that do not have a Profit Systems board installed.

A program to change the amount of memory that DOS allocates for itself is included. The system board switches can be set to show less memory than is actually installed, so that when the PC is first turned on, it runs a less time-consuming memory test. Once the test is finished, the Profit Systems memory size set program can be used to change the allocation of memory. The program is also useful to test programs to see if and how they work with different memory sizes.

QUADRAM (QUADBOARD)

Diagnostic software for memory, clock/calendar, serial ports, and parallel ports (in BASIC) is included with the Quad-Board. A program to switch LPT1: with LPT2: is included.

SEATTLE COMPUTERS (RAM+3)

Four LEDs on the upper part of the board are used to locate bad chips in the event of a memory problem.

The memory test software includes four tests that run consecutively; at any time during the test, the ESC key can be used to cause a summary of all errors encountered to be displayed.

The print spooler software was not available at the time of this writing, but should be soon, according to Seattle.

SIGMA DESIGNS (SDI-ESC+MEMORY)

The piggyback board, which can be added to the SDI-ESC+Memory board, has a second serial port on it. A cable is included for this second port.

Two separate manuals exist for the DOS 1.1 and DOS 2.0 versions of the electronic disk and print spooler programs.

STB SYSTEMS (RIO PLUS AND SUPER RIO)

The utility software includes these functions: pause display, slow display speed, disk name swap, print port swap, memory status report, video display disable, print pause, and clear spooler buffer.

The clock/calendar on the board uses an AA battery, which is supplied in a battery holder with double-sided adhesive. The battery bracket is designed to be attached to the inside of the PC, and a detachable wire is included to connect the bracket to the board.

TECMAR, INC. (1st MATE)

The clock/calendar software does not become an integral part of DOS; the DAIT and TYME programs are used instead of DOS's DATE and TIME, respectively.

The documentation says that a menu of spooled memory sizes will appear if the SPOOL program is run from DOS; this is true. The directions also state that if SPOOL —8 is typed, eight 8K blocks (64K total) will be set aside for spooling and the menu will not be displayed. This is not true; the menu is always displayed.

A program is supplied to abort spooled printing, this program makes no provision for freeing memory previously set aside for spooling, nor does it give any indication as to whether or not a print job was actually running at the time.

VISTA COMPUTER, INC. (MULTICARD)

There is a hole over the parallel printer connector on the mounting bracket. It is there so that the serial cable can be routed through. Because the cable is so short and the hole so small, it is very difficult to get the cable through the hole. However, Vista claims that this problem has been corrected in the new version of the board by moving the parallel connector down and marking the serial cable hole larger.

Extra documentation on disk is included as part of the package. Two separate files are supplied for DOS 1.1 and DOS 2.0 software documentation.

A program to change how DOS allocates memory is included. This program can be used to permanently change the included electronic disk software so that it uses any amount of memory which the user may specify.

supplying the new mounting brackets at the time of this review. However, this modification is such a minor one, the changeover to the new bracket should proceed very quickly. XT owners should make sure that the board of their choice is supplied with an XT-compatible bracket.

REFLECTIONS ON THE SURVEY

Several companies deserve special mention for high-quality documentation: Persyst, whose illustrations and photographs make configuration and installation a snap; STB, whose software documentation is excellent; and Indigo Data Systems, whose quick-reference cards are filled with useful information. QuadRam, IDE Associates, Tecmar, Profit Systems, Seattle Computer, and Vista Computer also provide high-quality documentation.

Profit Systems, STB Systems, and Persyst get high marks in software. Profit Systems' TascMaster (mentioned above) is a well-written, complete, and flexible program. STB Systems' software installation program handles all the details of setting up a disk to use each feature (electronic disk, print spooler, and utility software), and allows the user to selectively disable any of its functions.

Persyst's software is also friendly and easy to use. The Time Spectrum electronic disk and print spooler programs both have help screens that clearly explain the programs' operation and command syntax.

Although it was not possible to review every multifunction board on the market today, this survey should provide useful information concerning the various individual boards, as well as insights on what to look for in a PC expansion board.

everal companies deserve special mention for high-quality documentation: Persyst, STB, and Indigo Data Systems.

Names and addresses of companies mentioned in this article:

AST Research, Inc. (Megaplus and SixPakPlus)
2372 Morse Avenue
Irvine, CA 92714
714-540-1333
CIRCLE 475 ON READER SERVICE CARD

Computer Peripherals (PCM-PSC) 1117 Venice Boulevard Los Angeles, CA 90015 CIRCLE 476 ON READER SERVICE CARD

IDE Associates (IDEAboard)
44 Mall Road
Burlington, MA 01803
617-272-7360
CIRCLE 477 ON READER SERVICE CARD

Indigo Data Systems (Multipak) 100 East NASA Road, Suite 106 Webster, TX 77598 1-800-231-9480 CIRCLE 478 ON READER SERVICE CARD

LNW Computers (BusBoard)
2620 Walnut
Tustin, CA 92680
714-641-8850
CIRCLE 479 ON READER SERVICE CARD

Maynard (SandStar Series Memory Card) 400 Semoran Boulevard The Greater Mall, Suite 207 Casselberry, FL 32707 305-331-6402 CIRCLE 480 ON READER SERVICE CARD

Persyst (Time Spectrum)
15801 Rockfield Boulevard, Suite A
Irvine, CA 92714
714-859-8871
CIRCLE 481 ON READER SERVICE CARD

Profit Systems, Inc. (Addram Elite)
PO Box 1039
Berkley, MI 48072
313-559-0444
CIRCLE 482 ON READER SERVICE CARD

Quadram (QuadBoard) 4357 Park Drive Norcross, GA 30093 404-923-6666 CIRCLE 483 ON READER SERVICE CARD

Seattle (RAM+3) 1114 Industry Drive Seattle, WA 98188 206-575-1830 CIRCLE 484 ON READER SERVICE CARD

Sigma Designs, Inc. (SDI-ESC) 2990 Scott Boulevard Santa Clara, CA 95050 408-496-0536 CIRCLE 485 ON READER SERVICE CARD

STB Systems, Inc. (Super RIO and RIO Plus)
601 North Glenville, Suite 125
Richardson, TX 75081
214-234-8750
CIRCLE 486 ON READER SERVICE CARD

Tall Tree Systems (JEL, JFORMAT and JSPOOL)

1032 Elwell Court #124

Palo Alto, CA 94303

415-964-1980
CIRCLE 487 ON READER SERVICE CARD

Tecmar Inc. (1st Mate) 23600 Merchantile Road Cleveland, OH 44122 216-464-7410 CIRCLE 488 ON READER SERVICE CARD

Vista Computer Company, Inc. (MultiCard) 1317 East Edlinger Avenue Santa Ana, CA 92705 714-953-0523 CIRCLE 489 ON READER SERVICE CARD

	AST RESEARCH MEGAPLUS	AST RESEARCH SIXPAKPLUS	COMPUTER PERIPH. PCM-PSC	IDE ASSOC.	INDIGO DATA SYS. PC MULTIBOARD	LNW COMPUTERS BUSBOARD	MAYNARD ELECTRON. SANDSTAR MEMORY CD	PERSYST TIME SPECTRUM	PROFIT SYSTEMS ADDRAM ELITE	QUADRAM	SEATTLE COMPUTERS RAM + 3	SIGMA DESIGNS SDI-ESC + MEMORY	STB SYSTEMS RIO PLUS	STB SYSTEMS SUPER RIO	TECMAR 1ST MATE	VISTA COMPUTER MULTICARD
HARDWARE FUNCTIONS				(4)								31				
MAXIMUM MEMORY (K BYTES)																
ON BOARD	256	384	256	256	256	512	256	256	512	256	256	256	384	256	256	256
WITH PIGGYBACK	512			Z PENE			576	512				512		512		
RS232 SERIAL PORT	Υ	Y	Y	Y	Υ	M	M	Υ	γ	γ	Y	2P	Υ	2	Y	Υ
PARALLEL PRINTER PORT	0	Y	Y	Y	Y	M	М	Y	Y	γ	Y	Υ	Y	Υ	γ	Y
CLOCK/CALENDAR	Y	Y	Y	Y	Y	M	М	Y	Υ	Y	Y	Υ	Y	Y	γ	Υ
GAME ADAPTER	Article,	0				М	М					Y	Y	Y		
SASI HARD DISK PORT				Y	No. of the		М						Υ	Y		
WARRANTY PERIOD (IN MONTHS)	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	4
CABLES INCLUDED	Y	Y		Y	Y	Y	Y	Υ		Y	Y	γ	Y	γ	γ	Y
SOFTWARE																
DOS 2.0 COMPATIBLE	γ		Y	Υ	γ	Υ		Υ	Y	γ	γ	Υ	Y	Y	Y	Y
ELECTRONIC DISK	Y	Y			Y	Y	Υ	Υ.	Y	Y	Υ	γ	Y	Υ	Y	Y
SWITCHES SET TO FULL MEM.						γ	Υ	Υ	Y	Y	4.5		Y	Y		To her to
SWITCHES SET TO USER MEM.	Y	Y							PTEZ SE							236
EITHER					Y						γ	γ			Y	Υ
PRINT SPOOLER	γ	Υ Υ			. у	Y		γ	Y	Y	Y	γ	Υ	Υ	γ	
CLOCK/CALENDAR	γ	Y	Y	Y	Y	γ	Y	Y	. Y	Υ	Υ	Υ	Υ	γ	Y	Y
MULTITASKING									Υ	De S						
SCREEN DUMP					Υ					Santa Pila						
SELF-TEST	Fall II			Y						Υ	γ					
SPECIAL UTILITIES	Υ	Y								Y						Y
BOARD DESCRIPTION			75.00													
MODULAR BOARD ON MOUNTING BRACKET						Y	Y									
SERIAL CONNECTOR	γ	Y	Y		γ			Y		Y						
PARALLEL CONNECTOR									Y		γ	Y			Υ	Υ
9-PIN SERIAL CONNECTOR		WAS TO		Y	25.40				Y							
GAME ADAPTER CONNECTOR												Y				
CLOCK BATTERY												R 3 6 1				
REMOVABLE DISC	Υ			Υ		М	М				γ				Y	
PERMANENTLY ATTACHED			Y		Y			Y	Υ	Y		Υ				Y
MOUNTED IN PC CABINET							187						Y	Y		
EXTERNAL MNTG. BRACKET		ESTEET.						γ		160 50			Y	Y		to the
XT BRACKET INCLUDED	γ	γ		Y		Y		Υ	Υ			Υ	Y	Y		
DOCUMENTATION					9.4											
INFO ON 256K SYSTEM BOARDS	Y	Y			γ	Y		Y	Υ	Υ	Y	Y	Y	Υ	γ	Y
FITS IN GUIDE TO OPERATIONS	Y	Υ		Υ	Y			Υ	Y	Y		Y			Y	Y
REFERENCE CARDS					Y											
EXTRA DOCUMENTATION ON DISK	A SEC				Y			γ								Y
PRICE (RETAIL DOLLARS)		17 30 30														
64K MINIMUM CONFIGURATION	395	395	345	239	365	395	274	395	475	395	395	395	395	419	389	369
(NO MODULES ON MODULAR BOARDS)													0.0		007	007
MAXIMUM CONFIGURATION (MAXIMUM MEMORY, PARALLEL PORT, SERIAL PORT, AND CLOCK/CALENDAR ON MODULAR BOARDS)	1090	895	735	599	595	1250	1205	1175	1175	595	620	1065	845	1208	589	669

KEY TO TABLE 1:

0 = OPTIONAL

A NUMBER = NUMBER OF THE FUNCTION PRESENT ON THE BOARD

P = ON A PIGGYBACK BOARD

Y = YES

M = AVAILABLE ON A MODULE



PASSING THE LAB TEST

After a year in a physiology laboratory, a PC gets a strong endorsement

PETER AITKEN, PH.D.



Because most scientific data can be represented numerically, digital computers have long per-

formed a valuable role in scientific research, assisting in the analysis of experimental data. The rapid improvements in the performance, size, and price of computers have dramatically affected their laboratory applications. Below is a discussion of applications for the small computer drawn from the selection and use of an IBM PC for data collection and analysis in the Integrative Neurophysiology Laboratory at the Duke University Medical Center.

THE OLD DAYS

Not long ago, when the only available computers were bulky and expensive, computing power was centralized and shared. A university would, for example, have one large mainframe, possibly with a number of remote terminals, that was shared by all personnel—administration and faculty researchers. Data analysis was off-line, that is, measurements taken

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LAB TEST

in the laboratory would first be converted, if necessary, into numerical form to be entered into the computer at a later date—a tedious and time-consuming task. Even so, computer analysis was widely used and represented a great time savings.

If the analog data could be converted automatically to numerical form and then fed directly into the computer, efficiency would greatly improve. Enter analog-to-digital (a/d) converters, which convert an analog signal (voltage or current) to a binary numerical form and thus make laboratory measurements directly available to the computer. Although this method is powerful, it is limited in application by the size and cost of computers, preventing all but well-to-do laboratories from dedicating a computer to do one task.

When relatively small yet powerful computers became available at prices small and medium-sized laboratories could afford, major changes in laboratory uses of computers began to occur. Equally important - if not more so-was the introduction of computer systems with hardware and software specifically designed for laboratory use so that a scientist could exploit the computer's power without being or hiring a computer expert. Perhaps the best known early example of such a system is Digital Equipment Corporation's PDP-8/Lab series introduced about 12 years ago. It provided laboratory data collection and analysis capabilities at a price ranging from \$10,000 to \$20,000. By today's standards, of course, the price/performance ratio was high and the software cumbersome and limited. But at the time it seemed awesome.

The past few years have seen an explosion in laboratory-oriented computers and accessories. Indeed, the number of products and the number of companies marketing them make selecting a computer system for a laboratory a formidable task, as I found out when asked to select one for the Duke Neurophysiology Laboratory. Preliminary investigations revealed

three fairly distinct categories of available systems, covering a wide range of prices, capabilities, and convenience factors. It quickly became clear that there is not always a direct relationship between price and capability; thus, buyers should have a clear idea of their needs and should

hen relatively small yet powerful computers became available at prices small and medium-sized laboratories could afford, major changes in laboratory uses of computers began to occur. Equally important—if not more so—was the introduction of computer systems with hardware and software designed for laboratory use.

consider the amount of programming they are willing to do in order to select a system that will do the most for the least cost.

OUT THERE

The most sophisticated (and expensive) laboratory computer systems are those whose hardware and software have been designed specifically as an integrated package for laboratory use. In this category fall DEC's NINC System, Laboratory Technology Corporation's LABTECH 70, and Hewlett Packard's 9836. These are powerful, 16-bit systems with integrated interfacing components and data acquisition and analysis software.

Next come integrated data acquisition systems, which are designed to interface with personal computers. These systems, such as Cyborg Corporation's ISAAC for the Apple-II and the Series 500 from Data Acquisition Systems for the IBM-PC and Apple, consist of an external cabinet or con-

sole that connects by cable to one of the computer's slots; the console contains a/d and d/a converters, clocks, Schmidt triggers, and other interfacing hardware. To some extent these systems can be customized to meet the specific needs of the user. They come equipped with a package of software routines for data collection and analysis, instrument control, and graphics. While I have not used the systems in this category, their published specifications compare favorably with those of the fully integrated systems like MINC, usually at about half the price.

The least expensive route to computer data collection is to add a single-board, analog interface to a personal computer and write a program for it. For those not afraid of getting involved with hardware or of writing the necessary software, this approach can result in a powerful system obtained at a surprisingly reasonable price. This is the approach used at the Duke Physiology Laboratory.

LABORATORY PC REQUIREMENTS

The research projects currently underway here involve testing animals in an effort to advance the understanding of certain diseases of the nervous system such as epilepsy, in order to find more effective medical treatments. Data collection needs vary considerably; at times it is necessary to sample one or two electrical signals rapidly for a short period-1,000 samples over one-tenth of a second. Other experiments require that as many as six or eight signals be sampled slowly, perhaps once per second, over a period of several hours. Further requirements were d/a capacity in order to permit the computer to control external instruments; several high-resolution internal clocks for timing functions; digital input/ output lines for further control and sensing; and graphics. These requirements, common to most laboratory situations, would have been well met by any system in the first two catego-



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ries above. However, it soon became apparent that even the least expensive of these systems was beyond the laboratory's budget.

Because the necessary programming skills were available on our staff, we opted for a system from the third category, a personal board analog interfacing system.

WHICH PERSONAL COMPUTER?

Considerations of hardware and software availability quickly narrowed the field to two choices: the Apple II+ (the Apple IIe had not yet been introduced) and the IBM PC. At first, the Apple seemed the logical choice because several other nearby laboratories were already successfully using Apples in applications similar to the ones we needed. Thus, not only had the Apple been shown to be capable of performing the tasks we needed, but there was a library of software from which to draw and an informal users group with whom to talk.

The more I talked with people who were using the Apple, the more apparent became their dissatisfaction with the machine's inherent limitations. Although many complaints dealt with the Apple's processing speed, gripes focused more commonly on its memory limitations. With only 64K for operating system, program, and data files, some users found that their data collection and analysis abilities were severely limited. The IBM's vastly larger memory capacity and faster processing speed began to seem all the more appealing.

HARDWARE ADDITIONS

The next step was to find an analog interfacing board for the PC that would meet the laboratory's needs. Without an appropriate board, the PC's greater speed and memory would be all but lost. At the time of our search (fall, 1982), only one firm, Tecmar, was marketing such boards. Fortunately, one of their models, the Labmaster, offered all the features we needed: 16 to 12 bit a/d channels

onsiderations of hardware and software availability quickly narrowed the field to two choices: the Apple II+ (the Apple IIe had not yet been introduced) and the IBM PC.

(with optional expansion to 256 channels, 5 clocks/counters, 24 digital input/output lines, and a/d conversion speeds up to 40 K Hz. An IBM PC with the Labmaster board seemed to fill the lab's current needs, and it offered future potential. (In addition to the Labmaster, Tecmar also has the Labtender, which offers many fewer features than the Labmaster at a significantly lower price. Data Translation also recently introduced its DT2801 I/O board for the PC, which is similar in capabilities to the Labmaster. Both Tecmar and Data Translation also offer, at additional cost, packages of software routines to implement the functions of the boards.)

Only two software statements are required to program the Labmaster; in BASIC these are the INP and OUT statements. The IBM PC has 65,535 input/output ports; 16 of them are used by Labmaster. Some of these ports, called control parts, are used to send information to Labmaster; control parts, as the name implied, serve to control the board's functions. Some ports are used to receive information from the Labmaster, such as the board's current status or the results of the last a/d conversion.

A major reason for choosing the PC was its memory capacity. For additional memory beyond 64K on the system board, we chose an AST Research MegaPlus board with 256K. Besides memory, this board provides a parallel printer port, a serial port, and a clock/calendar with battery back-up. We use a black and white

monitor, but decided on the IBM Color Graphics board for its graphics capabilities. Two 320K disk drives and an Epson MX-80 printer (with Graftrax to allow printing of graphics), completed the hardware.

PROGRAMMING LIMITATIONS

Our initial software acquisitions were fairly straightforward—PC DOS with BASIC, the IBM Macro assembler, and a few utilities for functions such as print spooling, RAM disk emulation, and graphics screen dump to the printer. Because I was already familiar with BASIC, I chose that as my programming language, with assembly language subroutines when more speed was necessary.

In the course of writing our first data collection programs, however, the limitations of interpreted BASIC began to surface. Processing speed leaves much to be desired, of course, but of greater concern was the difficulty of interfacing assembly language subroutines to BASIC programs. This problem seemed insoluble until I learned that early versions of the IBM BASIC manual contained incorrect directions for BASIC-assembly language interfacing. Once the correct directions were in hand, the interfacing process worked, but the procedure was still cumbersome.

The other limitation, even more serious, was the BASIC interpreter's 64K maximum size for program plus data. This limitation negated most of the advantage of IBM's greater memory size, and, as my programs grew in complexity, it began to place major constraints on our work.

All of these problems were solved with the purchase of an IBM BASIC compiler. This is a powerful and useful piece of software that, in my view, belongs in the library of anyone using BASIC for serious programming. Although this article is not the place for a detailed description of the compiler, several of its features that relate directly to our problems deserve mention.

AT LAST!

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LAB TEST

First, compiled BASIC runs much faster than interpreted, by a factor of approximately 10. Second, interfacing BASIC and assembly language programs is much simpler because it is done automatically by the linker rather than through the tedious application of the DEBUG program, as when using interpreted BASIC. Third, compiled BASIC provides 64K for the program plus another 64K for data arrays—a doubling of available memory. Fourth, the compiler allows the omission of line numbers from all program statements except those referred to by GOTOs, GOSUBs, and other branch instructions. This allows for more compact and easily readable source code, as shown in the accompanying BASIC program listings 1, 2, and 3, which follow this article.

Listing 1, ASSEMBLY.TXT, is a complete listing of an 8088 assembly language subroutine named

DSCOPE1, which, when called by a BASIC program, collects and averages sweeps of analog data on Labmaster channel 0; the collection sweeps are triggered by pulses on Labmaster channel 7. In general, this program component is used for fast sampling of short-duration signals. In our lab, it is used to collect and average responses of brain cells that have been triggered by electrical stimulation.

Listings 2 and 3, BASIC1.TXT and BASIX2.TXT, are fragments of a large data collection and analysis program, written in BASIC for the IBM BASIC compiler. BASIC1 is the data collection part of the program, which works in conjunction with the ASSEMBLY.TXT. It sets up a clock on the Labmaster board to run at the desired sampling rate and also passes parameters—such as the address of the array in which the data are to be stored and the number of sweeps to average—to the assembly language

subroutine, DSCOPE.1. BASIC2 permits already-collected waveforms to be plotted on an X-Y plotter. It converts data into appropriate X and Y values and then sends the commands to the digital-to-analog converters on the Labmaster board.

The PC for our lab has served us well. For an investment of approximately \$6,000, we have a data collection and analysis system whose capabilities rival those of systems costing two and three times as much. It has met every need so far, and we have not come close to exploiting all its capacity. During a year of heavy use we have experienced no hardware failures and, with the exception of the problem with the BASIC interpreter mentioned above, no software bugs. This system should be seriously considered by anyone needing a laboratory computer system.

LISTING 1 ASSEMBLY.TXT

```
; This program collects and averages sweeps of analog data from
; channel O of the labmaster board, with each sweep triggered
; by a pulse on channel 7. It requires that the calling program set
; up clock 5 to output pulses at the desired sampling rate, and
  that the Labmaster be jumpered for external start a/d conversions
  The calling program must also pass two parameters: the address of the
; array for data storage, and the number of sweeps to be averaged.
; Program now collects 640 points/sweep. Subroutine "beep" beeps the
; speaker after each sweep. Maximum sampling rate=40kHz.
sseg
                segment stack
                                         ;set up stack.
                        20 DUP (?)
                ends
sseq
dseq
                segment
                                         ;set up data segment.
array
nswps
dseg
cseg
                segment public 'CODE'
                                         ;code segment.
                assume cs:cseg,ss:sseg,ds:dseg
                                         ;declare "dscopel" public so it can
                public dscopel
                                         ;be called from another program.
                        far
dscope1
                proc
                push
                                         ;save register.
                mov
                mov
                        si,[bp]+8
                                         ;get first parameter passed by
                                         ; calling program.
                        dx,[si]
                mov
                                         ;data array address in "array".
                mov
                        array, dx
                                         ;get second parameter passed.
                mov
                        si,[bp]+6
                mov
                        dx.[si]
                mov
                                         ;# sweeps in nswps.
                                         ;now nswps=#sweeps+1.
;now we go thru the array and zero all elements.
                mov
                        bx, array
                                         ;bx points at base of array.
                mov
                        si O
                                         ;si indexes array element.
```

	mov	ax,0	
zero_loop:	mov	[bx][si],ax	;move "0" to array element.
	add	si,2	;point at next element.
	100p	zero_loop	;loop back if cx<>0.
· ·			
;now we wait f	or a syn	ich pulse on a/d	channel 7.
;			
synch_loop:	nop		
	dec	nswps	;nswps now = # sweeps remaining.
	jz	done	;if it's 0, we're done.
i			
wait_synch:	mov	dx,0714H	;point at control byte.
	mov	al,10000000B	;disable autoincrement and
	out	dx,al	;all interrupts.
	inc	dx	;point at a/d channel byte and
	mov	a1,7	;specify that next channel
	out	dx,al	;to convert is #7.
	inc	dx	;point at a/d start & hi data.
	in	al,dx	;read high data to reset
			;done bit.
	out	dx,al	;start a conversion.
	mov	dx,0714H	;point dx at status byte
wait_done:	in	al,dx	;and read it in.
	стр	al,10000000B	;see if bit 7 is set.
	jb	wait_done	;if not, look again.
VALUE OF THE PROPERTY OF THE PARTY OF THE PA	inc	dx	;point at low data byte.
	in	ax,dx	;read ch#7 voltage.
	стр	ax,1024	;is it > "1024"?
	jl	wait_synch	;if not, try again.
;			
;now that a sy	nch puls	e has been recei	ved, we can collect data
3		A Paragraphic Control of the Control	
get_data:	mov	cx,640	;cx will count loops.
	mov	si,0	;si=array offset pointer.
	mov	bx,array	;bx=array base pointer.
	mov	dx,0714H	;point at control byte.
	mov	a1,10000100B	;enable external starts and
	out	dx,al	;disable autoincrementing.
	inc	dx	;point dx at 0715H.
	in	ax,dx	;read data to clear "done"bit.
	mov	a1,0	
4-4- 1	out	dx,al	;specify a/d channel #0.
data_loop:	dec	dx	;point at status byte
in_loop:	in	al,dx	;and get it.

mov

cx,640

;cx counts array elements.

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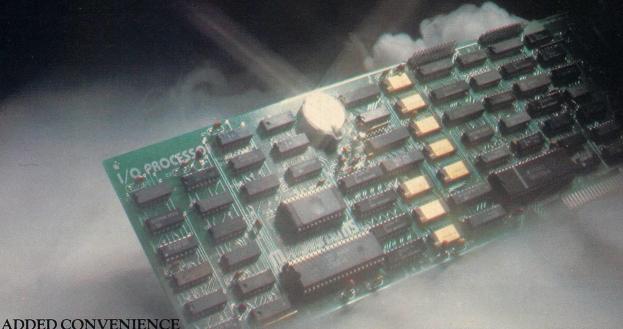
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```
; is bit 7 set?
                         al.10000000B
                cmp
                                          ;no, try again.
                ib
                         in loop
                                          ;point at 0715h.
                inc
                         dx
                                          ;get data word and
                         ax,dx
                in
                         [bx][si],ax
                                          :add it to array.
                add
                                          :point si at next array element.
                add
                         $1.2
                                          ;and loop back if 640 pts haven't
                1000
                         data loop
                                          ;been collected, i.e., if cx>0.
                                          ;point at control byte.
                der
                         al.10000000B
                                          :disable autostart.
                mov
                out
                         dx,a1
                call
                         beep
                                          :beep speaker.
put "x" plus 2 spaces on screen to indicate sweep.
                nush
                         ax
                                          :save registers.
                push
                         bx
                push
                         bo
                mov
                         bh,0
                                          ;select display page.
                                          ;character "x"
                 mov
                         a1,120
                mov
                         ah.14
                                          ;write, advance cursor.
                 int
                         10H
                         ah .14
                mov
                         a1,32
                                          ;character " ".
                 mov
                 int
                         10H
                 mov
                         ah.14
                mov
                         a1.32
                                          ;character " ".
                 int
                         10H
                pop
                         bp
                                          ;restore registers.
                 DOD
                         bx
                 pop
                         ax
                 jmp
                         synch_loop
                                          ;go wait for another pulse.
done:
                 nop
;now go back thru array dividing by # sweeps.
                         si,[bp]+6
                mov
                                          ;now dx has # sweeps.
                 mov
                         dx,[si]
                                          ;now nswps has # sweeps.
                         nswps,dx
                mov
                         cx,640
                                          ;cx will count loops.
                mov
                                          ;move array element to ax.
                         ax,[bx][si]
div loop:
                 mov
                                          ;convert to db1 word.
                cwd
                                          ;divide by # sweeps.
                 idiv
                         nswps
                         [bx][si],ax
                                          ;put quotient back in array.
                mov
                                          ;point at next array element.
                 add
                         51,2
                         div loop
                                          ;loop back if all not done.
                 100p
                DOD
                         bp
                                          :restore bp.
                sti
                ret
dscopel
                endp
;this subroutine "beep" plays a tone on the speaker - desired duration
; (in milliseconds) and frequency (in Hz) are placed in bx
;and di, respectively.
beep
                proc
                push
                                          ;save registers.
                         ax
                push
                         hx
                push
                         CX
                push
                         dy
                push
                         di
                mov
                         di 500
                                          ;set frequency.
                                          ;set duration to 50 msec.
                mov
                         bx.50
                         a1.086H
                                          ;write control byte to timer mode req
                 mov
                         43H.a1
                out
                         dx . 14H
                mov
                                          :to get desired freg, we must send
                         ax, 4F38H
                                          ;the value 1331000/freq to timer 2.
                mov
                div
                         42H, a1
                                          :write low byte to timer 2.
                out
                 mov
                         al, ah
                         42H, a1
                                          :write high byte to timer 2.
                out
                 in
                         a1,61H
                                          :get current timer port setting.
                         ah, al
                                          :save it in ah.
                mov
                                          ; change bits 0 and 1 and send to timer
                         a1,3
                or
                         61H, a1
                                          :port, which turns speaker on.
                out
hold it:
                         cx,280
                                          ;wait 1 msec.
                mov
                                          ;this loop cycles 280 times in one
                100p
                         beeping
beeping:
                                          ;msec.
```

```
;has the count expired?
                 dec
                                            ; if not, go back for another msec.
                         hold it
                 jnz
                                            ;recover port value.
                 mov
                          al,ah
                 out
                          61H, a1
                                            ;speaker off.
                 DOD
                          di
                                            ;restore reg.
                 pop
                          dx
                 DOD
                 pop
                 pop
                 ret
beep
                 endp
                 ends
cseq
                 end
```

LISTING 2 BASIC1.TXT

'This is a portion of a BASIC data collection program that uses the Lab-'master board to collect fast sweeps of analog data with the assembly 'language subroutine "DSCOPEI". The Labmaster should be jumpered for '"external start conversions" from clock 5, i.e., so that each pulse 'from clock 5 initiates an analog-to-digital conversion. The following 'lines of code set up clock 5 to run at the desired sampling rate.

```
set up labmaster board
                           ' reset "done" bit by reading high data byte
' write control byte - disable everything
391
        I=INP(&H716)
        OUT &H714,128
                           ' set data pointer to master mode register
        OUT &H719.23
        OUT &H718,0
                           ' set up master mode reg
        OUT $H718, 128
        OUT &H719.5
                           ' point to counter mode reg of counter 5
        OUT &H718.33
                           ' set up counter 5 for: no gating, count
        OUT &H718.11
                           ' rising edge of F1, disable special gate,
                           ' reload from load, count repetitively, binary count,
```

' count down, active-high TC pulse.

'clock 5 is now set to count down from a preset value to zero at a rate of 'l megahertz. Each time the clock reaches zero it will output a pulse, 'trigger a conversion, and start again. The preset value determines the 'number of counts done and therefore the conversion rate. The desired 'conversion rate (in KHz) is in p%(2); the following code calculates the 'desired preset value from p%(2) and loads this value into the counter's 'load register.

```
TIME0%=INT(1/(P%(2))*500)
TIME2%=INT(TIME0%/256)
TIME1%=TIME0%-256*TIME2%
OUT &H718,TIME1%
OUT &H718,TIME2%
```

nswps%=p%(1)

return

'the clock is now set - the next line starts it running

```
OUT &H719,112

screen 0
LOCATE 8,28 : PRINT "WAITING FOR SYNCH PULSE"

locate 11,32 : print "SWEEPS COLLECTED"
```

'p%(1) holds the number of sweeps to be collected (1-24). The next 3 lines 'display the numbers 1 thru p%(1) in a row across the screen - the subroutine 'DSCOPE1 places an "x" below each number as the sweeps are collected.

```
locate 14,((80-p%(1)*3)\2)-2
for i%=1 to p%(1) : print using "###";i%; : next
locate 16,(80-p%(1)*3)\2
```

'set up parameters to be passed to collection routine - the number of sweeps 'to collect and the address of the first element of the data array,

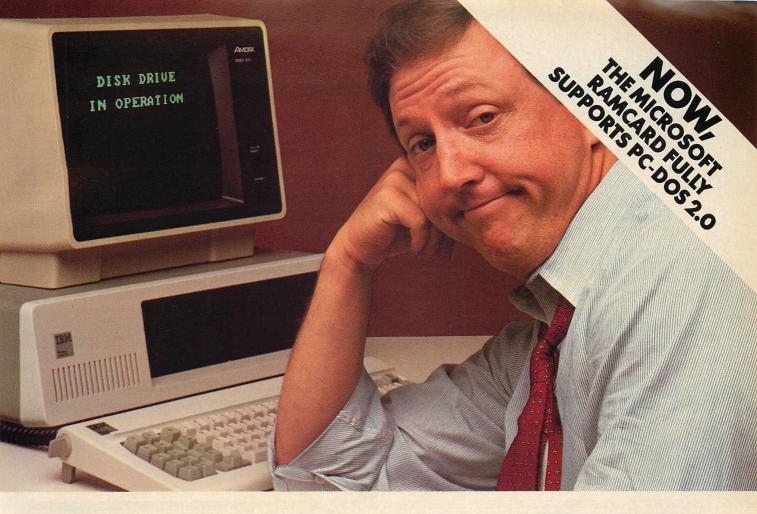
```
. X1%=VARPTR(X%(O,RN%))

'call collection routine

. CALL DSCOPE1 (X1%,nswps%)

. 'upon return, reset clock 5 and return to menu

. OUT &H719. 255
```



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LISTING 3 BASIC2.TXT

'This program section allows the waveform stored in an array to be plotted on 'an X-Y plotter using the 2 digital-to-analog converters on the Labmaster board. The waveforms are stored in the integer array x% which has been 'dimensioned x%(645,29). The array x%(a,b) is used as follows: b (0 thru 29) is the run number; for each level of b the actual waveform values are 'stored in a=1 thru a=640.

CLS : PRINT "Routine for X-Y recorder plots of waveforms" : PRINT PRINT "Connect d/a channel 0 to X-input of recorder," PRINT "Connect d/a channel 1 to Y-input of recorder." : PRINT

'now get run number of desired waveform

INPUT "Run number (1-30) to plot":PLOTRUNZ

'make sure the input value are within range

IF PLOTRUN%<1 OR PLOTRUN%>30 THEN PRINT "Out of range" : GOTO 2350

'since array is dimensioned 0-29, must subtract 1 from PLOTRUN%

PLOTRUNG=PLOTRUNG-1

'zero plotter pen by commanding both d/a converters to zero volts

OUT &H711,0 : OUT &H710,0 : OUT &H713,0 : OUT &H712,0

INPUT "Lower pen, hit return for plot (enter M for menu)";K\$ IF K\$="M" OR K\$="m" THEN GOTO 290

'calculate and send values to d/a converters

'p%(7) is a parameter set in another part of the program - it determines how much of the waveform is plotted. Its value is always 640, 320, or 160.

DI %=640/P%(7)

'loop once for each data point

FOR I%=1 TO p%(7)

'the d/a converters are 12 bit, but we can send only 8 at a time; the value 'to be sent must be divided into a low byte and a high byte (the left 4 bits 'of the high byte are ignored).

'calculate the x-coordinate

HIGHO%=INT(1%*3*DL%/256) LOW0%=1%*3*DL%-256*HIGHO%

'calculate the y coordinate

HIGH1%=INT(X%(I%, PLOTRUN%)/256) LOWIX=XX(IX.PLOTRUNX)-HIGHIX*256 IF HIGH1%<0 THEN HIGH1%=16+HIGH1%

'send the x value to d/a 0, the y value to d/a 1

OUT &H711, HIGHO% : OUT &H710, LOWO% OUT &H713,HIGH1% : OUT &H712,LOW1%

'now a delay loop because the computer is faster than the plotter

FOR K=1 TO 20 : NEXT K

NEXT 1%

'done, so beep and return

BROTHER HR-1A

BEEP : return

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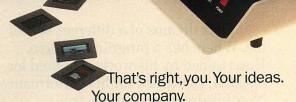
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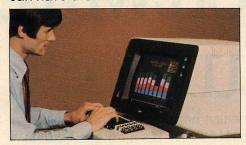
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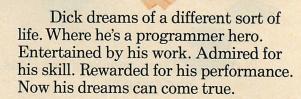
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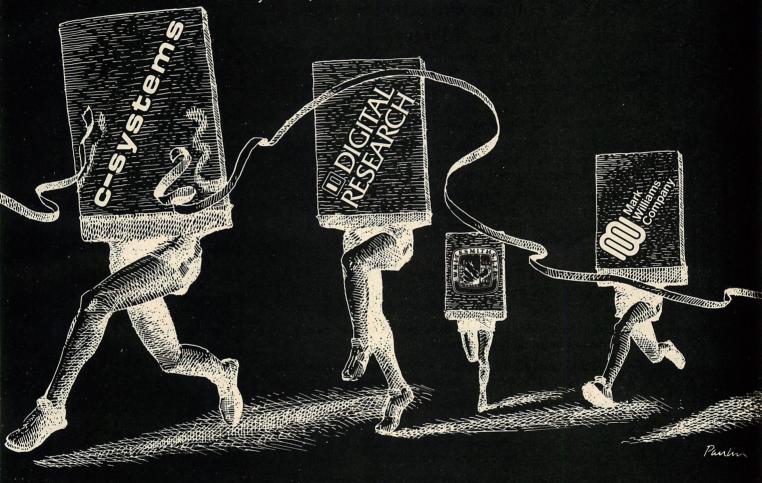
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Cand the PC: Part 2

BILL HUNT

Compilers from Digital Research, Whitesmith's, C-Systems, and Mark Williams



This is the second part of a review of nine C compilers. Part one (PC TECH JOURNAL Nov/Dec 83), included reviews of five C compilers for the IBM PC in the PC-DOS environment: Computer Innovations C86 compiler (Cl-C86), Lifeboat Lattice C (Lattice C), Microsoft C (Lattice C), C-Ware C compiler (C-Ware), and Manx Aztec C86 (Manx C). What follows is a review of four more compilers: Digital Research C, Whitesmiths C, C-Systems C, and Mark Williams Cl-C86. As in part one, this review uses the

criteria presented in the article also by Bill Hunt, "How to Choose a C Compiler" (PC TECH JOURNAL July/Aug 83) and gives results for several benchmark tests. To facilitate comparisons, the tables accompanying this article include the results for compilers reviewed in the previous issue.

The author reports that in spite of his best efforts he was not able to include all the C compilers that appear to be available. Norell Data Systems' C subset compiler, for instance, was listed in the Norell catalog for

some time, but was never completed. Telecon Systems has been selling a C compiler for the IBM PC for some time, but a review copy was unavailable. Likewise, the author was unable to get a copy of Intellect Associates' compiler. SuperSoft was marketing a C subset compiler for the CP/M80, CP/M-86, MS-DOS, UNIX and Z-8000 environments. SuperSoft's new PC-DOS version of the compiler was not available at this writing.

Bill Hunt is writing a book on C compilers.

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FEATURES

Table 1 compares compilers according to the following criteria.

Using the compiler. The Digital Research and C-Systems compilers are too large to fit well on two double-sided floppy disks. A hard disk or a RAM disk is necessary with these compilers unless you can tolerate changing floppy disks during each compile and link process. The Whitesmith's and Mark Williams compilers will be a tight fit but probably acceptable. I would recommend only the C-Ware for a system with singlesided disk drives.

All the compilers can compile small programs (60 lines) at an acceptable speed. The C-Systems compiler becomes quite slow for source files of 150 lines or more. All of the others are adequate or better. The fast compile times of the Lattice C and C-Ware compilers make them nicer to use than the rest of the group.

In addition, all the compilers displayed syntax error messages identifying the line where the error was detected. The CI-C86 and C-Ware compilers recovered better after syntax errors than the other compilers.

Supporting the Clanguage.

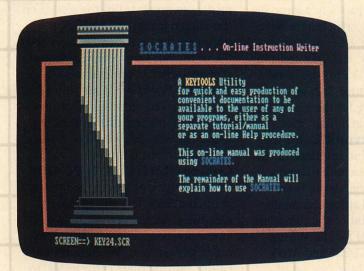
The C-Systems compiler does not support float variables or float arithmetic. This may be crucial or insignificant, depending on the application. The other compilers reviewed here support the full C language.

The Manx C compiler does not support bit fields; however, this is not a serious omission. The C-Ware compiler, on the other hand, supports the full language, but it requires that identifiers be declared before use.

The Standard C Library. All of the compilers reviewed support the standard library functions listed in the earlier article "How to Choose a C Compiler."

The Whitesmith's package includes a library of functions similar to the standard C library. Provided with all Whitesmith's compilers, these functions are sometimes the

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C AND THE PC

same as the standard C functions, sometimes different. Some support is provided for the standard C library but the documentation is inadequate.

The release of the C-Ware compiler reviewed in part 1 had some significant omissions, which have been rectified in release 2.1.

CI-C86, Manx, and C-Systems include the source files for the library—a big plus. Lattice, Inc. sells the library source code for the Lattice C library separately at a high price.

Expanding Beyond C. All the compilers provide an interface for using functions in assembler language, with documentation varing from thorough for the Lattice C compiler to adequate for most of the compilers to quite inadequate for the Whitesmith's compiler. CI-C86 and Mark Williams provided the best set of functions to access PC-DOS and the ROM-BIOS services. C-Ware and C-Systems provided functions for using

nly CI-C86 and
Lattice compilers
provide methods to
exclude library functions.
Although most other compilers do incorporate some
mechanism, users will have
to discover it for themselves.

BIOS keyboard and screen services. Lattice, Manx, Digital Research, and Whitesmith's provided access for the simplest DOS function calls only.

Only CI-C86 and Lattice compilers provide the methods and information to help exclude library functions if that should prove necessary. Although most other compilers do incorporate some mechanisms, users will have to discover and understand them for themselves.

Memory Usage. All of the compilers support separate 64K limits on program code and data. The C-Sys-

tems compiler allows a 1 megabyte limit for code as an option. The Digital Research compiler alone in the group supports a 1 megabyte limit for data. (Results of using that memory model are presented in the section on the Digital compiler.) None of the compilers documents adequately the use of the 8088 segment registers, although Lattice C comes close.

Mark Williams, Whitesmith's, and Lattice can produce .COM files with programs and data limited to a single 64K area as an option. It is not very useful, but it is free.

Compatibility with PC-DOS. CI-C86, Digital Research, and Mark Williams compilers all provide the user the choice of performing End-of-Line conversion and Control-Z sensing or bypassing it. Whitesmith's and Lattice provide these conversions, too, but their mechanisms for disabling these services are clumsy. The other compilers do not provide these services in a useful way.

The C-Ware and Whitesmith's compilers use DOS 2.0 I/O support. The C-Ware implementation is quite elegant—a single set of functions is linked into the user program. When executed, it checks to see if it is executing under DOS 2.0 or DOS 1.1 and uses the appropriate DOS services. The Whitesmith's compiler provides a choice of I/O functions when the program is linked.

All of the compilers except C-Ware supported I/O redirection under DOS 1.1. Only the C-Ware compiler produced programs that worked when DOS 2.0 redirected input to a file; all the others crashed the PC when executed with input redirected by DOS. The Whitesmith's compiler malfunctioned in different ways depending on whether DOS 2.0 or DOS 1.1 I/O functions were used.

Programs produced with the C-Ware compiler did not crash with DOS 2.0 input redirection, with one exception. The GETCHAR() function does cause program crashes. As this function is often used with redirected input, this is unfortunate.

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C AND THE PC

BENCHMARK RESULTS

Table 2 shows benchmarks for compilers reviewed in the last issue, as well as those in this review.

Compile Times. Two sets of compile time figures are reported—one with all files on floppy disks and one with all files on a RAM disk. If you

use a hard disk or have only some files on a RAM disk, your times should lie between these extremes. DOS 2.0 with 12 I/O buffers defined was used in collecting these times, which seem reproducible within one to two seconds on my system. Others may measure somewhat different

times, but the differences between compilers should stay the same.

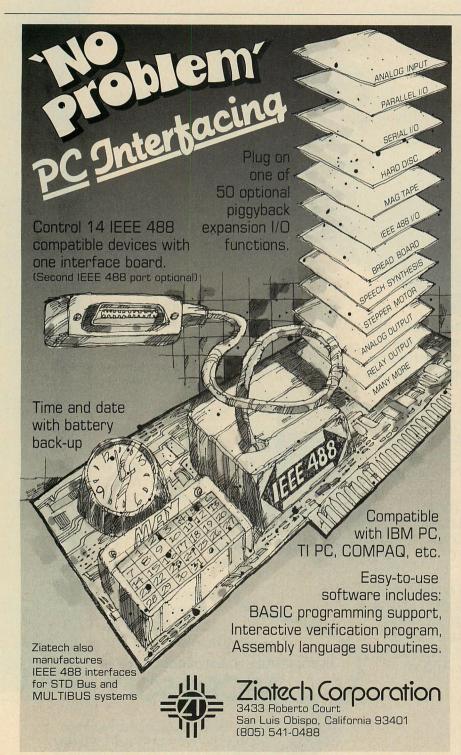
The C-Ware compiler is the champ for compile speed. Version 2.1, received since the first review was published, is about 2 seconds faster than the earlier version on the 150- and 400-line programs. The linker provided with this compiler is also very fast. Recompiling and relinking are quick enough that you don't lose your concentration while you wait.

The Lattice C compiler is not quite as fast but is still significantly faster than the rest. CI-C86, Manx C, Whitesmith's, and Mark Williams are similar in compile times, whereas the C-Systems compiler is much slower on the 150 and 400 line files.

For the compile-time tests, the Digital Research compiler was run with optimization disabled. In real use, this would be done for all but the final compilation of a source file. Although the RAM disk times are quite good, the size of the compiler and the other programs would require a 400-500K RAM disk to keep everything on-line. The floppy-disk based times for the Digital compiler put it in the middle of the pack. Link Times. The link times suggest that the IBM linker used with the Lattice C and C-Systems compilers is not bad. Only the C-Ware linker is faster; the Digital Research, Whitesmith's and Mark Williams linkers are much slower.

Pentathlon. The pentathlon program's benchmarks give a mixed result. No compiler wins all the benchmarks. The variation in times for the floating-point benchmark is quite large - almost a factor of 3. This would be quite significant if you cannot use an 8087 chip. The next three benchmarks-function calls, string copy, and character count-show less variation among compilers. The Whitesmith's and Lattice compilers are the fastest, with the C-Ware compiler close behind. The C-Systems and CI-C86 compilers are slower by about 50 percent.

The file-copy benchmark with



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C AND THE PC

Feature Price	Computer Innovations C86 \$395	Lattice C* \$500	C-WARE C \$100	Manx Aztec C86 \$249	Digital Research C \$500	Whitesmiths C \$550	C-Systems C \$195	Mark William CC-86 \$500
Version Tested	1.33d	1.04	1.7	1.05i	1.04	8/83	1.8	0.5
Using the Compiler								
Size of disk files	195K	220K	139K	200K	268K	190K	275K	216K
Fits on 2 Fl. Disks	tight	tight	easy	tight	no	tight	no	tight
Compile speed	good	very good	great	good	good -	good	poor	good
Syntax Error Messages	good	good	good	fair	fair	fair	fair	fair
Language—Full C	yes	yes	yes	almost	yes	yes	no float	yes
Std. C Library								
All std. fun. provided	yes	yes	yes	yes	yes	yes	yes	yes
Usage documented	good	good	fair	fair	very good	awful	fair	good
Source listing	yes	по	no	yes	no	no	yes	no
Expanding beyond C								
Asm Interface	yes	yes	yes	yes	yes	yes*	yes	yes
PCDOS + BIOS access	full	limited	some	limited	no	limited	some	some
exclude library fun.?	yes	yes	partial	yes	yes	yes*	partial	no
Memory Usage								
Max program size	64K	64K	64K	64K	64K/1M	64K	64K/1M	64K
Max data size	64K	64K	64K	64K	64K/1M	64K	64K	64K
Size of C pointers	16 bits	16 bits	16 bits	16 bits	16/32 bits	16 bits	16 bits	16 bits
Doc. of 8088 segment register usage	poor	good-	fair	fair	fair-	poor	fair-	no
Compatibility with PC-DOS								
End-of-Line Conversion?	good	good-	poor	no	good	yes	no	good
Can it be disabled?	yes	clumsy			yes	clumsy	_	yes
Ctl-Z sensing?	yes	good-	fair	no	good	yes	no	good
Can it be disabled?	yes	clumsy	no		yes	clumsy	_	yes
DOS 2.0 Support	not yet	not yet	no	no	no	yes	no	no
Does I/O redirection?	yes	yes	no	yes	yes	yes	yes	yes
Works with DOS 2.0 redirection?	crashes	crashes	crashes	crashes	crashes	crashes*	crashes	crashes

TABLE 2: C COMPILER I	BENCHMARK	RESULTS						
	Computer Inno-		C-WARE					
Benchmark	vations C86	Lattice C*	C	Manx Aztec C86	Digital Research C	Whitesmiths C	C-Systems C	Mark Williams C-86
Compile Times (in sec.)								
Seive 60 lines	18-37	6-25	4-22	15-32	12-35	19-50	34-54	12-42
Pentathlon 150 lines	48-73	22-56	10-33	39-62	22-49	59-97	143-172	28-64
Big file 400 lines	105-132	39-98	16-51	81-113	41-75	103-150	281-328	47-96
Link Times (in sec.)								
Sieve 1 file	23-39	13-55	6-34	16-53	36-70	32-95	17-42	23-57
Pentathlon 6 files	25-41	16-42	7–40	19–59	39–77	37–97	20-46	35–79
Pentathlon (in sec.)								
Floating Point 10 iterates	33	48	27	41	27	75		36
Function Calls 10 iterates	18	13	12	21	16	14	20	15
String Copy 10 iterates	31	19	21	26	24	22	25	18
Character Count 10 iterates	23	16	17	16	15	12	22	13
File Copy 2 iterates	146	48	52	42	77	75	76	52
(getc/putc) 30,000 bytes								
100-Yard Dash (in sec)								
File Copy 1 iter.								
(read/write) 30,000 bytes								
512 bytes per read	37	14	14	15	15	15	14	26
1024 bytes per read	32	19	9	9	20	9	8	26
8192 bytes per read	28	27	5	5	27	4	6	26
To/from RAM disk	23	3	2	1	3	2	2	13
Prime-Number Sieve (in sec)								
10 iterates	19	11	12	18	12	13	20	12
Register Variables (in sec)								
String Copy 100 iterates	307	192	205	155	155	155	194	126
Sieve 100 iterates	180	105	116	150	94	92	166	90
Program Sizes (in bytes)								
Sieve	16,438	13,824	8,192	13,120	25,088	14,736	14,080*	10,236
Pentathlon	17,640	15,360	13,824	14,688	26,624	17,056	15,232*	14,511
Sieve (no I/O)	6,902	7,680	2,048	4,176	13,312	3,354	12,032	7,612
(*See text for explanation.)								

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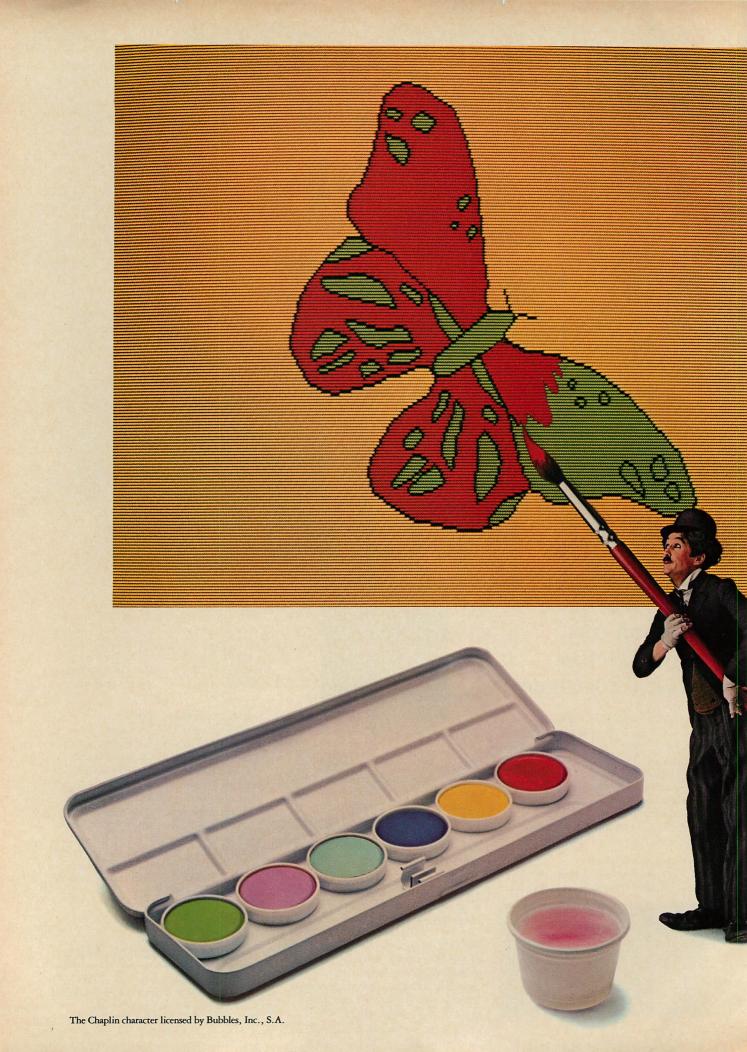
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C AND THE PC

GETC and PUTC functions shows a significant amount of variation. Lattice C, C-Ware, and Manx C are relatively fast; Digital Research, Whitesmith's and C-Systems compilers are 50 percent slower and CI-C86 is 100 percent slower.

100-yard dash. This program measures low-level I/O speed using the read and write functions. The program was modified for each compiler to suppress any End-of-Line conversion or Control-Z recognition. The times for the C-Ware compiler shown here are different from those in the first part of this review: they were obtained under DOS 2.0 with the current release of the C-Ware compiler. The Whitesmith's compiler provides two I/O libraries - one for either DOS 1.1 or 2.0 or one for DOS 2.0 alone. The times shown are for the DOS 2.0 library. The C-Ware, Manx, Whitesmith's, and C-Systems compilers are all fast and use PC-DOS's capabilities well. Lattice C and Digital Research do I/O in a CP/M style and perform less well. CI-C86 is just plain slow-it is slow when accessing a RAM disk.

The Manx and C-Systems compilers produce good results for DOS 1.1 or 2.0, while the C-Ware and Whitesmith's compilers produce 14 to 27 second times under DOS 1.1.

The Mark Williams compiler library includes no low-level I/O functions. The test was run using the buffered I/O functions FREAD and FWRITE. While the result is not terrible, it is disappointing.

The sieve benchmark has several winners and a few losers. The differences among Lattice, C-Ware, Digital Research, and Whitesmith's are insignificant. The others—CI-C86, Manx C and C-Systems—are grouped about 60 to 80 percent slower.

The CI-C86, Lattice, and C-Ware compilers treat register variables as regular local variables. The other compilers allocate 8088 registers for register variables, whereas the character count benchmark makes use of register variables while the string

copy and the sieve benchmarks do not. I revised these benchmarks to make use of register variables as well. The results naturally favor the second group of compilers. The Mark Williams compiler produces the best results in this test, with the Whitesmith's and Digital Research compilers not far behind. Users who are careful to make good use of register variables may find that one of these compilers may be faster overall than Lattice C in an actual application. But the simplistic approach to supporting register variables taken by these compilers extracts a penalty on every function call, whether register variables are used or not.

f floating point operations are important in your application, get a C compiler with 8087 support. Of the four compilers, the Whitesmith's and digital compilers are significantly better than the C-Ware compiler. The CI-C86 compiler, with an 8087, beats any software-only compiler but is no match for the other compilers with 8087 support.

Program sizes for the sieve and pentathlon programs are also shown in table 2. The significant differences are that C-Ware produces especially small programs and Digital Research produces overly large ones. The figures for the sieve program without I/O functions show that several of the C compilers can produce quite compact programs.

8087 Support. Since I finished this article, I was able to re-run the floating point benchmark using the 8087 floating point chip. Results are shown

below for the four compilers that provide 8087 support. The moral is simple: if floating point operations are important in your application, get a C compiler with 8087 support. Of the four compilers, the Whitesmith's and Digital Compilers are significantly better than the C-Ware compiler. The CI-C86 compiler, with an 8087, beats any software-only compiler but is no match for the other compilers with 8087 support.

Floating Point with the 8087

CI-C86 5.8 seconds
C-Ware 2.5 seconds
Digital 1.7 seconds
Whitesmith's 1.5 seconds

DIGITAL RESEARCH C

Digital Research recently announced that it was making many of its language compilers, including the C compiler, available for utilization under PC-DOS on the IBM-PC.

Compile times are not bad as long as optimization is disabled. You will need to have either a hard disk or a large RAM disk (200K or more) in order to avoid changing disks during each compile and link operation.

Execution times are pretty good—at the top of the heap for floating point, character counting, and the sieve program. However, the 20 seconds the compiler spends on optimization do not yield much of a return.

Compiled programs are significantly (8K to 12K) larger than are programs for the other compilers.

Along with the compiler itself come the Programmer's Utilities-a relocating assembler, a linker, and a library manager. These tools are functionally the same as those Digital Research supplies in the CP/M-86 environment and are to be used in place of the IBM assembler and linker. The assembler supports few of the features in the IBM assembler, such as macros, structures, or assume statements. The linker has some useful features as well as some explanation of the linking process and of what the parameters mean. Users who are already familiar with these tools from



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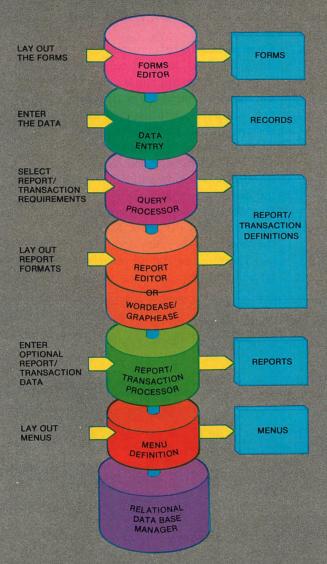
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C AND THE PC

the CP/M-86 environment may like DR's approach; however, most C users will probably find this to be less satisfactory than using the standard IBM assembler and linker.

The big news about this compiler is that it supports four different memory models. Limits of 64K or 1 megabyte can be selected separately for both the program (code) and the data it uses. DR calls these choices memory models after Intel's termi-

Table 3: Digital Research Compiler Memory Models

		Memory Model	_
Benchmark	Small	Medium	Big
Pentathlon (in sec	conds)		
Float	27	28	30
Func. Calls	16	18	18
String Copy	24	25	100
Char. Cnt.	15	15	23
File Copy	77	77	545
(getc/putc)			
Sieve	12	12	17
Program sizes (in	bytes)		
Sieve	25,088	28,160	36.864
Penthathlon	26,624	29,696	38.400
	20,024	27,070	50,400

nology. Here is what they mean: **Small Model.** Program code is limited to a maximum of 64K. All data—including constants and dynamically allocated data—must fit in its own area of 64K maximum. This is the memory model used by the other compilers tested.

Medium Model. Program code may use up to 1 megabyte of space. Data is limited to 64K as in the small model.

Compact Model. Program code is limited to 64K. Data declared within functions (automatic storage class or the stack) is limited to a maximum of 64K. Constants, static data and data declared outside functions (external data) are limited to a separate 64K area. Data allocated dynamically through alloc and free functions may use up to 1 megabyte.

Big Model. Program code may use up to 1 megabyte of space. Data use is the same as in the compact model.

The medium and big models offer worthwhile capabilities; are they usable? I ran the pentathlon and sieve benchmarks using the small, medium, and big models. (Results for the compact model would closely resemble those for the big model so it was not included.) The results are shown in table 3. The medium model is as fast as the small model except on the function call benchmark where it is about 10 to 15 percent slower. The big model is another story, as the following ratios show:

	Ratio of big/small model
Benchmark	times
Floating Point	1.1
Function Calls	1.1
String Copy	4.0
Character Count	1.5
File Copy (getc/putc)	7.0
Sieve	1.5

Program sizes are also shown in table 3—the medium model costs about 3K and the large model 12K. I think that the medium model is a

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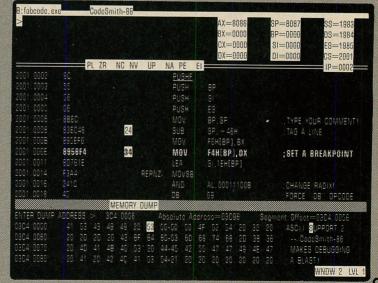
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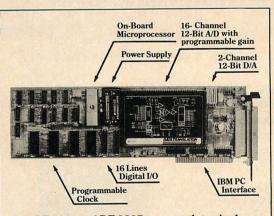
The complete DT2801 I/O system fits on just one board. It includes A/D with programmable gain, D/A, digital I/O, and a programmable clock and has direct memory access capabilities. The DT2805 features the same functionality, with provision for low level analog input.

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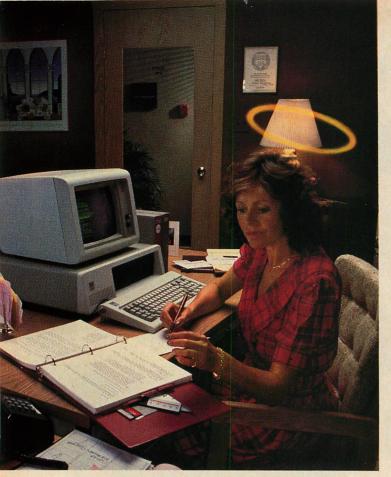
The DT 2801 and DT 2805 are complete single board data acquisition systems for the IBM Personal Computer.

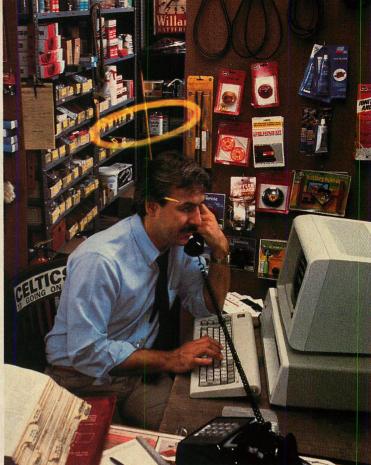
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C AND THE PC

useful feature but the big model is too slow to be useful.

One compiler pass can provide a disassembled listing of the object code that the compiler produces from a C source file. I used this listing to inspect the code being produced. The quality of code produced for the small model suffered because the SI and DI registers were reserved for unused register variables. The big model code used calls to library routines for all pointer operations, even fetching and storing data via pointers.

Users of this compiler are dependent on Digital Research for support and technical advice. Experts on the IBM Assembler or the Linker will have no experience with DR's tools in the PC-DOS environment. Most of the experts on DR's tools will be limited to the CP/M-86 world.

The Digital Research compiler is typical of ambitious software projects when first released - too large, too slow, and not fully documented. Its small and medium models are usable

now, but its unique feature—the big memory model - will require a quantum jump in speed before it is useful. One or two more releases will probably fix this compiler's growing-pains.

WHITESMITH'S C

This is a specialized product. It is a compiler written by sadists for masochists. If you need this kind of product, nothing else will come close.

The main problem is the documentation. Two manuals are provided: the C Programmers' Manual, which applies to all Whitesmith's compilers, and the C Interface Manual for 8086. The C Programmers' Manual describes the C language and the libraries supplied with it. No details specific to the 8086/8088 processor or to the IBM PC-DOS version are given. The 8086 manual is divided into sections with a general section and three sections covering one operating system each. One of those sections covers both the MS-DOS and CP/M-86 versions of the compiler.

No instructions are provided for compiling and linking programs in the PC-DOS environment. Batch files for compiling and linking are included, but their choice of options is not documented and they do not allow for use of standard C library functions or generation of .exe files.

No effort is made to explain the function of the many compile and link options in the PC-DOS environment. Numerous options must be specified with mysterious values to produce usable PC-DOS programs. These parameters are shown in a few examples but never explained in the context of PC-DOS. The explanations that are provided apply to several operating systems and often are completely incorrect for the PC-DOS implementation. Here are sample commands for the link step:

to produce a .com file link -htr -tb0x100 -ed edata -eb memory -o PROG.com -1 chdr.o PROG.o libc.86



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C AND THE PC

to produce a .exe file link -tb0x100 -db0 -ed edata -eb_memory chdr.o PROG.0 libc.86 to86 -exe -b0x4000 -o PROG.exe

The two examples above are used to produce two different kinds of programs - .com files and .exe files. The manuals do not discuss the two memory usage models, nor do they give clear procedures for producing each kind of file. The batch file provided for linking programs procudes works only for .com files, not for the more useful .exe files.

The manuals are not organized by function but by the internal structure of the product. If you want to know whether file I/O functions recognize control-Z as the end of a file you may have to read all of the documentation to find out. No index is provided for either manual.

Topics such as file I/O or linking are covered in several places with implementation-specific sections contradicting the general sections. No crossreferencing is provided to guide you through the manuals.

The error messages produced by the various compiler and linker programs are not explained. Incorrect settings of parameters can produce such messages, but requirements for setting parameters are not discussed.

Compiler features are explained in a jargon derived from a dialect spoken by UNIX techies. Even if you understand it, you will not understand how it applies to the PC-DOS environment and Whitesmith's is not wasting their time helping you.

These problems with documentation may seem minor annovances that resolve themselves after a few days. My experience is that these problems will remain. The compiler and linker is much more complex than any other product I tested, and without adequate documentation, almost impossible to use effectively.

What about the compiler itself?

It is good but does not offer anything unique. Is it worth putting up with the documentation? No. The installation process allows you to choose DOS 1.1 or DOS 2.0 versions of the compiler. What Whitesmith's do not tell you is that the DOS 2.0 procedure assumes that you have a hard disk defined as drive C. If you do not have a drive C: defined, the installation procedure will not work. No. mention of these assumptions is made in the installation documentation. Compile times are average and program execution times are quite good for most of the benchmarks.

The 400-line big source file produced spurious syntax error messages. but removing a few blank lines made the error messages disappear. Blank lines seem to produce nonsense error messages in other files also.

The compiler does use DOS 2.0 I/O functions, which gives fast file I/O performance and full access to hierarchical directories. However, I found bugs in this support both in



general notes. Rapid interaction between data bases allows records to be created easily and quickly. A password system keeps your data confidential.

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The PC212A eliminates the need for an asynchronous communications adapter card and external modem cable, this

alone saves you approximately \$190. The PC212A provides an extra 25 pin EIA RS232 interface connector, a telephone jack for alternate voice operation, and a telephone line jack for connection to the dial network. Without question, the PC212A is the most user friendly, most reliable, and best performing modem for your

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What's been the persistent dilemma in buying a printer for a personal computer? Top performance letter-quality printers have always been expensive. The lower priced attempts have proved clumsy, noisy, and slo-o-o-w. And don't be fooled by "correspondence quality" claims for matrix printers: there is no way around the fact that they produce characters from dot patterns. Letters and reports just don't look, well, *typed*. If you want fully-formed characters, and a true typewritten look, there is no shortcut. Now comes the perfect combination: a low-cost, truly letter-quality printer, with a housing that makes it look much more costly—and it is even fast! The Juki 6100.

We benchmarked the nearest approximations, the Silver-Reed EXP 550, the Brother HR-1, and the Smith-Corona TP-1. Good products all. But then we put the Juki 6100 through its paces against this checklist:

- 1. Print Quality
- 2. Print Speed
- 3. Noise level
- 4. Reliability
- 5. Warranty
- 6. Versatility
- 7. Physical Specifications
- 8. Ease of Installation & Use
- 9. Price
- 1. **Print Quality.** This is where it really shines. Our printer uses print wheels and ribbons designed not for computer printers, but for *typewriters*—where the standards for "letter quality" are set. The printwheels are Triumph-Adler style: true typewriter quality, because that's what they were designed for. What's more, the printer uses IBM's Selectric II typewriter cartridges, so enough said about

quality of the ink and the print impression. Chances are you already stock these cartridges in your supplies cabinet.

- 2. Print Speed. Using the standard Shannon test for plain text, we do a true 18 characters per second. That exceeds all three rival printers, and is half again faster that the Smith-Corona. But there is more. The Juki designers put in logic-seeking bi-directional printing and high speed motion over blank spaces. This means that typing speed on typical text is as fast as printers with much faster ratings. And there is a built-in 2,000 character buffer in the printer to free up your computer even before the printing is done.
- **3. Noise level.** Quiet level is more accurate. The technical rating is better than 62 dBA from 1 meter away. If you don't know a dBA from a D&B, it means no raucous clatter to rattle the nerves or jam your phone conversations, a big improvement over some printers we listened to. The other three are *two to eight times noisier*.
- **4. Reliability.** The engineers know what an MTBF of 2500 hours at 25% duty means. More meaningful for most of us: there are very few moving parts. Other printers employ a complex system of electric motors, wires pullies, and springs. Not only do they breakdown, they also go out of adjustment. But the Juki uses a far more elegant design: the printhead glides across a rail by magnetic traction. That's all there is to it. If you look inside, you will see a startling simplicity.
- **5. Warranty.** We give you a full 90 days limited warranty which covers parts and labor, but we don't think you'll be testing this part of our offer. Still, it's nice to know it's there. It means you really cannot go wrong by ordering and putting this printer through its paces.

and brought home a major discovery!

6. Versatility. The is a virtually unlimited choice of type styles to choose from—over 100 in the catalogue we checked. Our printer can print at 10, 12 and 15 characters per inch and also take Proportional Spaced wheels for that extra touch of class. We also have an economical and reliable bi-directional forms tractor as an option, if you want to handle continuous stationery, or print graphics including the use of reverse-paper motions.

We supply a 100-character Courier 10-pitch (characters per inch) printwheel with the full ASCII character set and extra Word Processing symbols. The other three printers can't match that: Smith-Corona has only 88.

7. Physical Specifications.

Print Speed: 18 characters/second

Daisywheel: Triumph-Adler compatible
Drops into place

Printing Characters: 100 per wheel

Printing Characters: 100 per wheel
Printed Line Length: 110 characters under 10 pitch

132 characters under 12 pitch 165 characters under 15 pitch

82 to 220 characters under proportional spacing mode

Horizontal Resolution: 1/120 inch minimum

Vertical Resolution: 1/48 inch (1/96 inch possible by using escape sequence)

Platen Size: 13 inches (Printing line 11 inches)

Ribbon: IBM82 Compatible multi-strike or single strike (Selectric II)

Interface: Centronics parallel

Power Consumption: 40 W idling, average 80 W printing Dimensions: Width: 20.5", Depth: 17.9", Height: 5.9"

Weight: 31 lbs.

MTBF:

Environment: Ambient Temperature: 41 ° to 95 ° Farenheit

Relative Humidity: 30% to 85% 2,500 hours at 25% duty

MTTR: 15 minutes

Noise: Less than 62 dBA at 1 meter distance

Buffer Memory Size: 2K bytes

Options: Bi-Directional Forms Tractor, \$169.00

- **8. Ease of Installation and Use.** The Juki is fully compatible with your IBM PC or XT. Just plug it into the parallel printer port.
- We don't send you on a search for a cable to make things happen. It's in the box.
- And it's exasperating to be all set to go—but no ribbon. So we give you a ribbon. Loading is clean and simple—it's an IBM Selectric style cartridge, remember.
- We also give you a printwheel: a courier 10 (characters to the inch), the most popular typeface. The fun comes in loading it: just pull back a lever, and **drop it in**. No cover or ribbon removal, no inky fingers. No figuring out why it doesn't attach. It drops into a recess and the printer engages it entirely on its own!
- And one more thing. In the continental United States, we pay the shipping!
- **9. Price.** \$579.00 complete with power cable, computer connection cable, printwheel, and ribbon cartridge, and freight. It's all there! Everything you need to have this handsome printer typing crisp, perfect pages minutes out of the box.

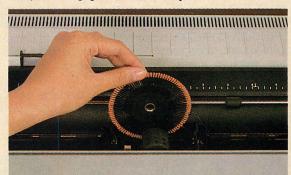
We wouldn't spend two pages if we weren't onto something big. Make the same discovery. Call us right now. Use our 800 number. Or fill in the card and mail. Ask for the following:

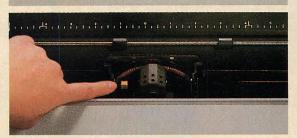
Juki 6100 Printer, with cable: J6100 \$579
Bi-Directional Forms Tractor (optional): J6150 \$169





Above: Easily accessed controls are on the front panel. The printhead, ribbon, and printwheel are mounted as a single mechanism. Below: The printwheel simply drops into place; the printer engages it automatically!





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C AND THE PC

compiled programs and in the compiler itself. The first pass of the compiler crashed when I specified a multi-level path name such as

c:/ccompile.dir/wsmiths.dir

for the location of include files.

Although the library that comes

with the compiler is extensive, it is only a distant cousin to a standard C library. The idea is that Whitesmith's has its own set of standards that applies to all its compilers from the DEC VAX to a CP/M-80 system. Users experienced with a Whitesmith's compiler who like it, should

feel more at home here. While there is some support for standard C library functions, it is not well documented.

I discussed with Whitesmith's my problems with the documentation and with the compiler's operation, and I learned that the company's point of view on this subject is that documenting normal operation of the compiler is not their responsibility. I was told that if I used any options other than those used in examples in the manual or in the compile and link batch files, I was on my own. Several years ago Whitesmith's was the only source of C compilers for microprocessors. If you wanted a C compiler, your choice was theirs or nothing and you were grateful for anything. Whitesmith's seems to feel that things have not changed.

"Q-PRO 4 blows dbase II away

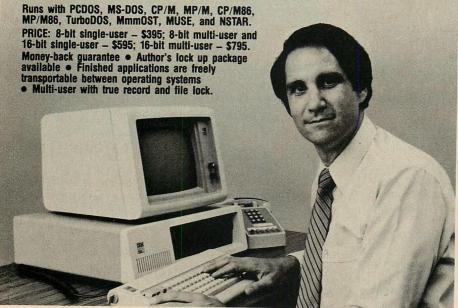
We now complete complex applications in weeks instead of months.

says Q-PRO 4 user, Richard Pedrelli, President, Quantum Systems, Atlanta, GA

As a dBASEII beta test site the past two years, we were reluctant to even try Q-PRO4. Now we write all our commercial applications in Q-PRO4. We find it to be an order of magnitude more powerful than dBASEII.

We used Q-PRO4's super efficient syntax to complete our Dental Management and Chiropractic Management Systems much faster. Superb error trap and help screen capabilities make our finished software products far more user friendly, too.

In my estimation, any application programmer still using outdated 3rd generation data base managers or worse, a 2nd generation language like BASIC, is ripping himself off. ###



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C-SYSTEMS

The C-Systems compiler accepts the full C language with one exception: there is no support for floating point. If you need floating point, look elsewhere. Aside from this limitation, this is a solid implementation of C—not a toy subset compiler. (C-Systems also sells the C-Window debugger.)

The compiler produces assembler source code for input to the IBM assembler. This accounts for the slow compile times shown in the results shown in table 2. The compile times for the C-Systems compiler are much longer for medium and large files than for any other compiler tested and are painfully so. C-Systems was testing its own assembler at the time this article was written. A preliminary check of compile times using this assembler in place of the IBM assembler suggests that compile times for the 150-line and 400-line programs might be reduced by 75 and 170 seconds respectively. This would still be slow, but more bearably so.

The 275K disk space requirement makes a hard disk or a large (320K) RAM disk very desirable, if not necessary. The IBM assembler contributes about 67K to this total. (The assembler that C-Systems is preparing is

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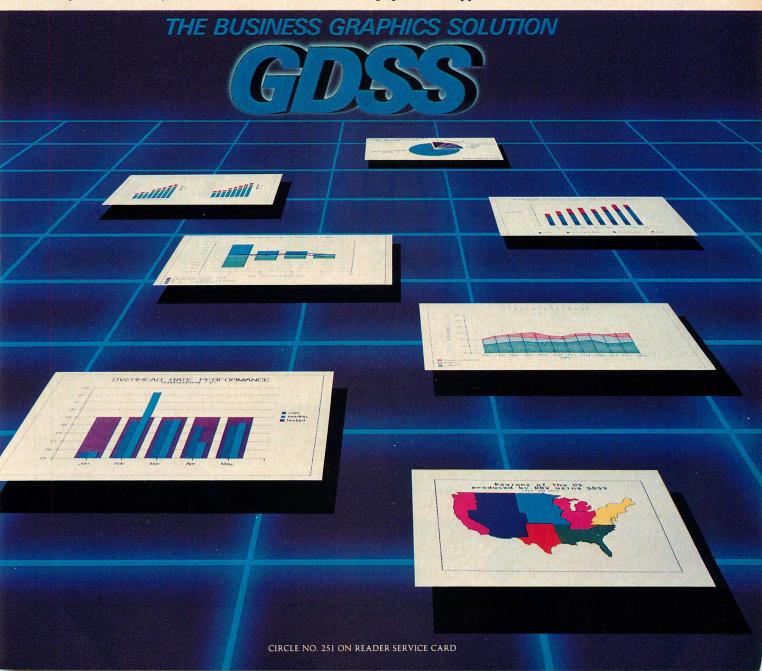
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C AND THE PC

about the same size.)

Handling of syntax errors has pluses and minuses. On the plus side, if the compiler finds any syntax errors, it exits as if control-break had been typed. This allows the succeeding assembler steps to be avoided. In addition, syntax error messages are clearly worded—more so than most of the compilers reviewed. The negative side is that the compiler does not recover well from syntax errors, so some of those clearly worded messages refer to spurious errors.

The best feature of the C-Systems compiler is its efficient implementation of low level file I/O. Along with Manx C, Whitesmith's, and C-Ware, this compiler has I/O functions fast enough to use in I/O applications.

Documentation is passable but somewhat below par. It does not use examples very well and is written as a technical description of the product rather than as an operations guide or a reference manual. The manual that I saw had no index but one was being added at the time of the review.

One consequence of generating assembler source code is that some variable names conflict with words reserved by the IBM assembler. The C-Systems manual warns of this problem and lists a few words such as ax, bx, and so forth, referring the reader to the IBM assembler manual for a complete list. Unfortunately, there is no complete list in that manual. This is an unnecessary annoyance—C-Systems should fix it.

Compared to the other C compilers, the C-Systems compiler is competent but not outstanding. Its slow compile times are a definite minus. However, the C-window debugging package is unique and worthwhile, and it works only with this compiler.

THE MARK WILLIAMS C The Mark Williams company has

been marketing a UNIX look-alike operating system for some time. Recently the company has begun to offer C compilers for the CP/M-86 and MS-DOS environments. The CP/M-86 version has been available for several months, but the MS-DOS version is brand new.

The product includes an assem-

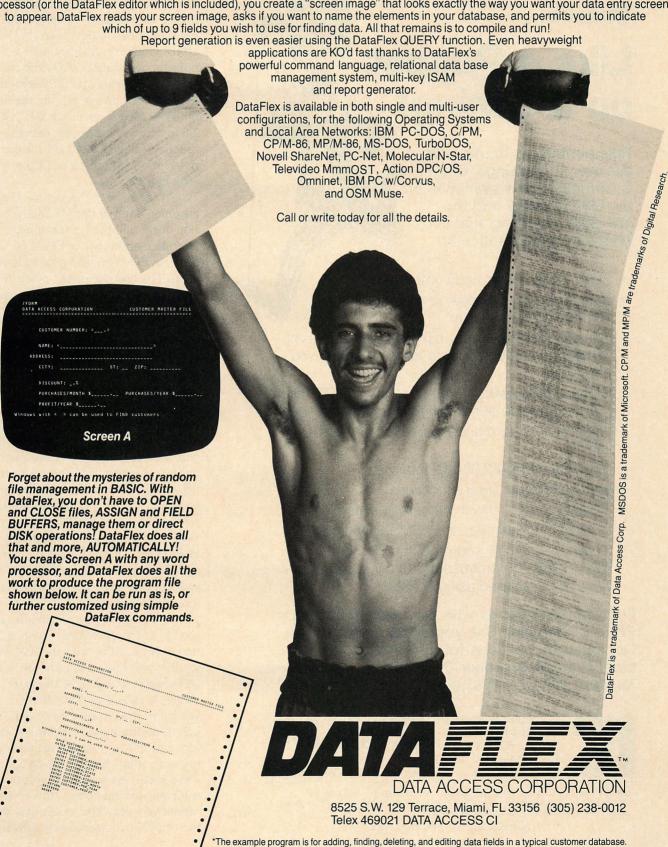
The product includes an assembler, a linker and a library manager in addition to the compiler itself. The assembler neither accepts the same syntax nor supports all the features of the IBM assembler. It should, nevertheless, be adequate for writing short assembler functions to be called from a C program. The linker has numerous options and requires lots of input to control them, even for a simple program. Fortunately, an executive program generates this input automatically in most cases. The assembler and linker do not offer any special advantages for general use. Most users would be better served if



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the compiler worked with the standard IBM assembler and Linker.

The library provided with the compiler is quite complete, containing all the standard C library functions and many others from the UNIX C library. Although the functions for accessing PC-DOS and the IBM-PC hardware are fairly comprehensive, they do not provide the flexibility needed for many of the DOS 2.0 services. A header file defines function call codes and the file-control block layout to make DOS services easier to use.

At the time of this review, the documentation of the MS-DOS version of the compiler is incomplete. Documentation for the CP/M-86 version was extensive and good in most areas. The documentation of the library functions was especially praiseworthy, approaching that of the Digital Research compiler library.

Although the Mark Williams C is not the winner in all the benchmarks but its overall performance, it is as good or better than any other compiler tested. The compiler's best feature is the speed of compiled programs. Another good point is the support for ASCII and binary files. Endof-line conversion and control-Z sensing are provided and can be disabled coveniently. One weakness is the absence of low-level file I/O functions. While the buffered I/O functions FREAD and FWRITE from the library are almost fast enough, this is a disappointment in a product clearly intended for serious use.

The Mark Williams compiler is a good product. With faster compilation, compatibility with the IBM assembler and linker, and low-level file I/O support, it would be the first choice. It should be noted that the version of the compiler reviewed here is preliminary. It performed solidly with no bugs discovered during my evaluation. Because the compiler was a preliminary version with incomplete documentation, this review cannot be a definitive evaluation. But the compiler compares well with any

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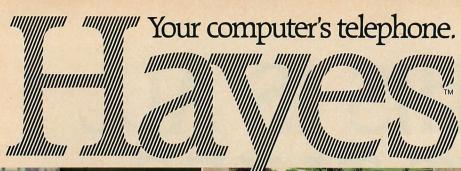
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C AND THE PC

of the others tested and therefore merits serious consideration.

SUBJECTIVE RATINGS

While my opinions about what is important in a C compiler were central in selecting criteria, I tried to stick to making measurements and reporting facts. To supplement the hard facts, I will report my subjective ratings:

Compile and Link Speed. Anyone who is a fanatic for fast compilation will find that only the C-Ware and Lattice compilers are fast enough to suit them. With most of the other compilers, waiting for a compilation to finish is a bit unpleasant. Waiting several minutes for the C-Systems compiler to finish is agony.

Finding Syntax Errors. I expect the compiler to find syntax errors for me. All the compilers find the first error adequately, but the CI-C86 and C-Ware compilers usually recover to find the rest of the errors. For the rest of the compilers the best policy is to fix the first error and ignore the other messages. The Manx compiler is especially bad about scrolling the good message off the screen as a multitude of spurious messages appear. Surely one screenful of spurious messages is adequate.

Convenient Batch Files.

When I start using a compiler, I set up two batch files—c.bat and 1.bat—for compiling and linking. I capture any special options and library file names that the compiler and linker need in the batch file so that I do not have to type them for each compilation or linking step. Here are some examples of use:

c sieve

1 sieve

1bench0 bench1 bench2 bench3 bench4 bench5

The 1.bat file should work for one file or for six files and should produce a program with the name of the first file on the line.

The CI-C86, Lattice C, C-Ware, and C-Systems products all allowed me to build suitable batch files and hide the details. In contrast, the same

job was hard to do with the Digital Research, Manx, Whitesmith's, and Mark Williams compilers.

Performance. All of the compilers produce programs fast enough for my current needs. None produces the kind of very compact and highly optimized programs needed for a large software product that strains the PC's resources. The differences in performance among compilers do not seem to be a good criteria for choosing a compiler.

Empathy With Me, the User. The CI-C86 compiler shows the best understanding of what I want my compiler to do. Compiler, linker, and library manager work without requiring any drama and have a clear, simple command syntax without requiring lots of strange options. The manual is sparse but got me started in a few minutes and provided me with quick answers to reference questions. The library includes the functions necessary to make use of PC-DOS and the IBM-PC hardware.

The Lattice compiler is better by most objective measures, but it is not as well fitted to the IBM PC or to my needs. The documentation is quite thorough, but it is hard to use as a reference document.

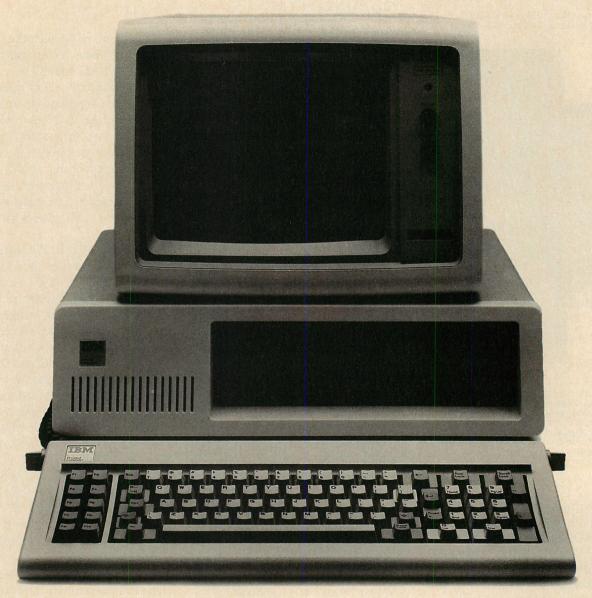
The C-Ware compiler is mostly heaven and part hell. The compiler itself is celestial, but the library I/O functions are poorly adapted to the DOS environment. The latest release of the compiler has removed many of the quirks, but some remain.

FINAL RECOMMENDATIONS

First one unequivocal recommendation: do not buy the Whitesmith's compiler. None of the other compilers is a loser. There are some winners, though, and here are my choices:

Best Buy: C-Ware. For \$100 you get a lot of brilliant work and some boneheadedness.

Best for Learning: CI-C86. (\$400) Everything works as it should, it is adapted to the IBM-PC and PC-DOS, and you get the source for the



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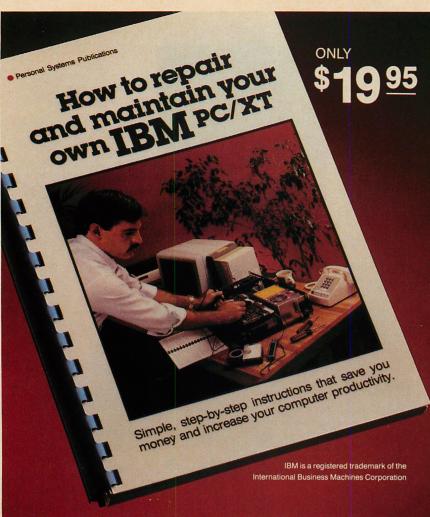


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C AND THE PC

library functions.

Best for Software Development: Lattice C (Lifeboat or Microsoft.) (\$500) It compiles fast and produces fast programs.

Best as a Personal Programming Tool: A toss-up among Lattice C, CI-C86, and C-Ware.

What about the others? Are there any reasons for buying them? The Mark Williams compiler generates fast programs. It is a strong alternative to the Lattice C compiler. The C-Systems compiler is the only one that works with their C-Window debugger. Even if you buy another compiler, you may want to use the C-Window package for debugging.

The Digital Research compiler is a good choice if you want to use Digital's tools or if you have been working in CP/M-86 environment. The support for program sizes over 64K may also be valuable.

The Manx C compiler is available for CP/M-80 and Apple environments. If you want to develop applications for all these environments, it is the only choice. For a portable compiler, it is quite good.

BRINGING IT UP TO DATE

One last caveat: Since this review was written, vendors may have fixed problems and included new capabilities in their products. You can use the results presented here to quiz vendors. The Digital Research, Whitesmith's, and Mark Williams compilers are quite new at the time of the review; they are likely to change significantly before the review appears. The bibliography at the end of the article lists some other reviews of C compilers which can provide a different perspective on the compilers reviewed here. Several C compilers not reviewed here are also covered in those articles.

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REFERENCES

Byte, August 1983. (Theme for this issue was the C language. Separate articles reviewed C compilers in the CP/M-80, CP/M-86, and IBM PC-DOS environments.)

Clapp, D., 1983. "C unveiled: Microsoft's C exceeds expectations." *PC Magazine*, October 1983, p. 503. (This contains no benchmarks nor comparisons to other compilers, or insights to using the product.)

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Hunt, B., "C and the PC, Part 1." PC Tech Journal, November-December 1983, p. 110. (Part one of the above review.)

Hunt, B. "How to Choose a C Compiler." *PC Tech Journal*, July-August 1983, p. 78. (The criteria used in my reviews are developed in this article.)

Norton, P. "Microsoft's C Compiler." Softtalk, August 1983, p. 72. (The Microsoft C compiler is described in comparison to IBM Pascal.)

List of Available C Compilers

Aztec C86 \$250

Manx Software Systems
P.O. Box 55
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CI-C86 \$395

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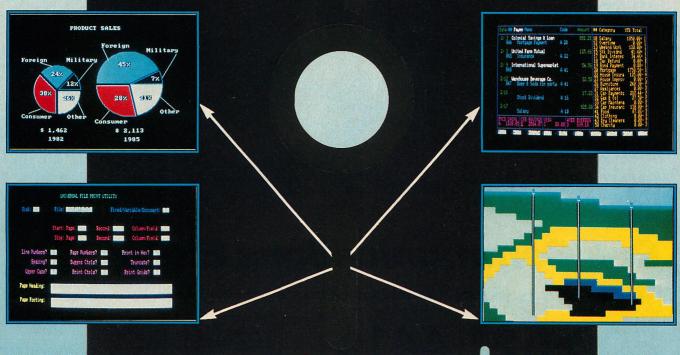
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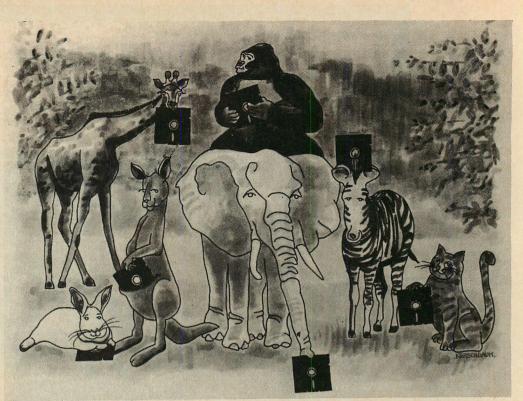
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The C-Window Debugger: A Tool for Testing

A good C compiler is a necessity for writing good software in C. But how about some help with debugging and testing C programs? The normal method is to imbed lots of PRINTF statements in a program to show what is happening. This is time consuming and requires rigid discipline to ensure that testing is thorough. Once the bugs are found, you remove these debugging PRINTF statements, only to replace them later when a bug shows up or when you change the program. While there are software engineering methods to deal with this problem, a good tool for testing would be welcome. The C-Window package produced by C-System's is such a tool.

What does the C-Window Debuggér do? Under control of C-Window, you can execute one line of the program at a time, trace the sequence of statements executed, and set breakpoints to halt the program at a specified line in the program. You can examine and alter variables in the program. The display shows the next line of the program to be executed (along with a few lines before and after it). It works like a good assembler

language debugger, but for C programs.

How is it used? Compile the source files you want to debug with the C-Systems compiler with the -w flag set, then link all the object files specifying the C-Window library in addition to the regular C-Systems library. When you run the program the C-Window debugger gets control as soon as any function compiled with the -w flag is entered. At that point, you can examine variables and control execution as you like.

Listing 1 shows a C program to count words. In listing 2 the same program has PRINTF statements added. Listings 3 and 4 show this program being tested with C-Window. The screen is divided into three windows: the top one shows commands addressed to C-Window and responses to those commands. The middle window is for normal STDIN and STDOUT console I/O communication with the program. It shows the input and output that would occupy the whole screen normally. The bottom window shows the current position in the C program. Lines of the program are displayed as they would be when printed. A line number and an arrow at the left side of the screen mark the next line to be executed. In listing 3 some data values are being displayed with C-Window commands. These commands accept any valid C expression. This allows you to use pointers and to look at any part of an array or structure. Decimal, hexidecimal, character, and string formats are provided for displaying data. Listing 4 shows the display command being used to set the variable FD to zero, the commands being used to set the variable FD to zero, the commands for executing a single line of the program (S), and for executing the program until a specified line is reached (G).

There were some minor, annoying limitations on assigning values to long integer variables in the version I tested.

The debugging process is quite interactive. When you display one value, it often suggests another value to examine or a test to run. Is it really effective? You still have to write some test functions and recompile frequently in order to fix bugs that you have discovered. But C-Window cuts preparation time and speeds the actual testing. It is most effective for tracking down bugs in whole programs and less so for testing individual functions. I could test programs without creating a printed listing of the program. Because few personal computers use a fast printer, this is significant.

Most assembly language debuggers allow you to change the current position in



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the program. C-Window cannot change the flow of control in the program. You can achieve the same result by changing the value of a key variable before it is tested in an if or while statement.

C-Window can handle programs composed of several source files, but you can only display and modify variables declared in the source file corresponding to the function being executed. This is annoving but not fatal. Another irritating limitation was the inability to use names assigned to constants in a source file.

What are the drawbacks to this tool? The slow compilation times of the C-Systems compiler defeat the purpose of a fast debugger. Even with the new assembler that C-Systems is testing, compile times will be irritatingly slow. Pairing C-Window with a really fast compiler such as the C-Ware or Lattice compiler would be

a major improvement.

Because the C-Systems compiler does not support floating point, the debugger is not useful for applications that require floating point.

The debugger's multiple window screen display does not work with console input and output that bypass the standard library functions. Writing directly to the screen or making calls to the Rom BIOS will overwrite the control information and the source listings.

C-Window adds about 37K to the size of the program being tested; you should plan to have at least 192K available (not counting any RAM space).

The C-Window library increases the on-line space needed by 70K to a total of 345K. You will need a large RAM disk or a hard disk to keep everything on-line. Changing disks twice during every compile and link operation defeats the purpose of a fast debugging tool.

C-Window costs \$195. But because it works only with the C-Systems compiler, the effective price is \$390 if you have a different C compiler. If you are serious about C it is probably worth it.

Of these drawbacks, only the slow compile speed and the requirement for the C-Systems compiler are serious. What is the verdict? The current C-Systems compiler is just too slow. When C-Systems solves that problem, C-Window will be a tool worth using. C-Window can be improved in many ways and C-Systems is busy doing just that. Displaying the C source program in a third window is a feature that has been added in the last month; more enhancements are under consideration. This is a worthwhile and exciting product with promise.

LISTING 1 WORD COUNT PROGRAM

```
/* wc.c - count words */
#include <stdio.h>
#define WORD 0
#define NOT WORD 1
FILE *fd ;
main(argc,argv)
int argc ;
 char *argv[];
```

```
int c;
long wc ;
if( argc < 2 )
 { printf("\n no name");
   exit(0);
fd = fopen(argv[1],"r");
                             /* open the file */
if( fd == 0 )
 { printf("\n can't open");
    exit(0);
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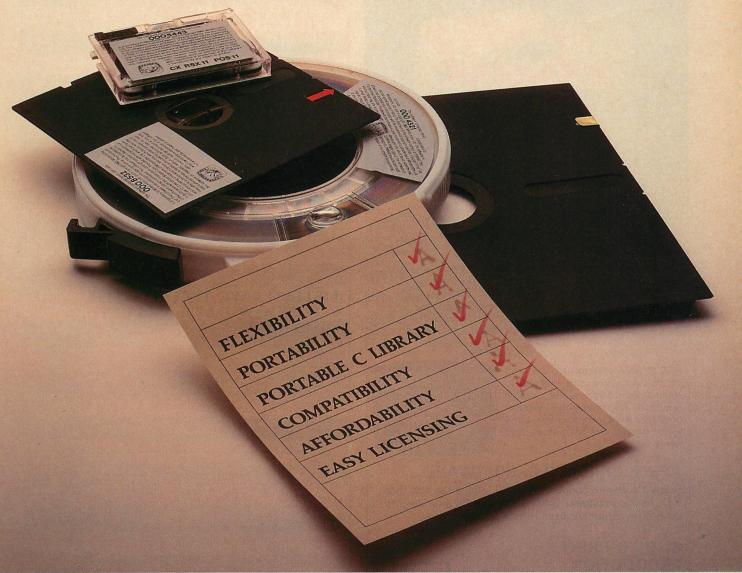
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```
while( skip(NOT WORD) != EOF )
                                    /* skip to beginning of next word */
    { wc++ ;
      if( skip(WORD) == EOF )
                                      /* skip to end of the word */
          break :
  fclose(fd) :
  printf("\n %ld words",wc);
int check(c)
                     /* classify a char as part of word or not */
      c = c & 0x7f;
      if( (c == ' ')
       || (c == '\c')
         (c == '\n')
         (c == ',')
(c == '.')
         (c == '(')
       (c == ')'))
         return( NOT WORD ) ;
      else return( WORD );
int skip(skip_type) /* skip chars of skip_type in file fd */
 int skip type ;
  int c;
  c = getc(fd);
  while( (c != EOF) && (check(c) == skip type ) )
  { c = getc(fd) ; } ;
  return( c );
  c = getc(fd);
  while( (c != EOF) && (check(c) == skip type ) )
LISTING 2 WC WITH DEBUGGING
PRINT F STATEMENTS
/* wc.c - count words */
#include <stdio.h>
#define WORD 0
#define NOT WORD 1
FILE *fd :
main(argc,argv)
 int argc ;
 char *argv[];
   int c :
  long wc ;
   if( argc < 2 )
    { printf("\n no name");
      exit(0);
  fd = fopen(argv[1], "r");
                              /* open the file */
   if( fd == 0 )
    { printf("\n can't open");
     exit(0);
  printf(" fd= %d \n",fd) ;
  while( skip(NOT_WORD) != EOF ) /* skip to beginning of next word */
      printf("\n after skip(NOT_WORD) \n");
      if( skip(WORD) == EOF )
                                    /* skip to end of the word */
          break :
      printf("\n after skip(WORD) \n");
  fclose(fd);
  printf("\n %ld words".wc):
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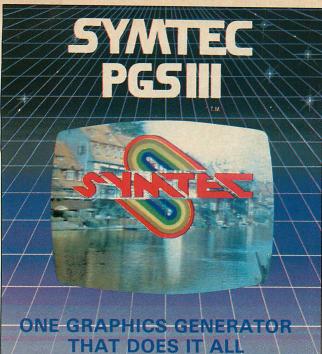
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C AND THE PC

```
int check(c)
                     /* classify a char as part of word or not */
   printf(" check-%x",c);
      c = c & 0x7f :
      if( (c == ' ')
       | (c == '\c')
          (c == '\n')
         (c == ',')
         (c == '.')
         (c == '(')
         (c == ')') )
         return( NOT WORD ) ;
      else return( WORD );
int skip(skip type) /* skip chars of skip type in file fd */
int skip type ;
  int c;
  printf("\n skip called - skip_type= %d \n", skip_type);
  while( (c != EOF) && (check(c) == skip type) )
   { printf(" loop-%x",c) ;
      c = getc(fd);
  return(c);
LISTING 3 WC TESTED WITH
```

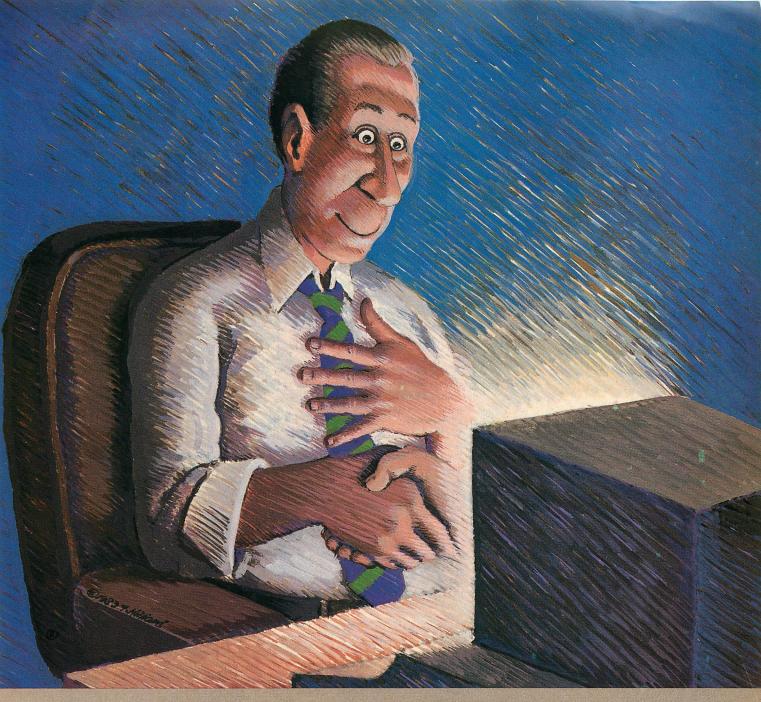
C-WINDOW-DATA VALUES DISPLAYED

```
c-systems c-window (tm) Version 1.2 (C)Copyright 1982, 1983 c-systems
>>d fd-> cnt
>>dc *(fd->_ptr)
b
>>d c
61
>>dc c
```

```
int c :
    c = getc(fd) :
    while( (c != EOF) && (check(c) == skip_type ) )
      { c = getc(fd) ; } ;
    return( c ) ;
```

LISTING 4 WC TESTED WITH C-WINDOW-SET VARIABLE FD TO ZERO

```
c-systems c-window (tm) Version 1.2 (C)Copyright 1982, 1983 c-systems
step at main line 16
>>d fd=0
0
>>g main,18
break at main line 18
>>ds argv[1]
test.dat
                              -----Function: main
        fd = fopen(argv[1], "r");
        if( fd == 0 )
    { printf("\n can't open");
            exit(0);
        wc = 0 ;
```



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Interrupts and the IBM-PC

t the heart of every workable data communications program for the PC is a solution to the lost data problem. How to guarantee that a program will always be prepared to handle incoming data. The solution, I've found, lies in the PC's flexible interrupt system, which can halt virtually anything, even DOS and BIOS routines, to deliver incoming data.

In part 1 of this article, we examined the workings of interrupts: How the 8259 interrupt controller watches for and prioritizes interrupt requests from peripherals, keeps track of servicing, masks unwanted requests, and more. We spent time in the depths of the 8259's microcircuitry, explaining how to guide its operations.

If last month's article can be thought of as time in the classroom,

PARTI

How to put together a terminal emulator using DUMBTERM.

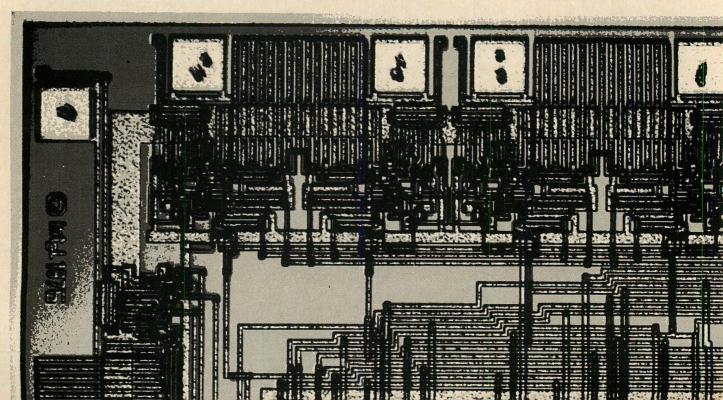
this month's is the field trip. As with most field trips, it helps if you bring along your field guide, in this case, the *IBM Personal Computer Technical Reference*. (I know you have one: You wouldn't spend three or four grand on your computer and then skimp on the forty bucks for the book that gives you the whole story on its inner workings—would you?)

This month, we'll describe how

to build a functional terminal emulator: Its unusual feature is that with it the RS232 input function is completely interrupt-driven, and will use the interrupt capabilities of IBM's asynchronous communications adapter. (Most non-IBM communications cards are functionally equivalent to the IBM adapter, so the program should work well with any of them.)

ABOUT DUMBTERM

The program (listing 1, which follows this article), is called DUMB-TERM: the terminal emulated is, in fact, a dumb terminal, as it is capable of very little processing of the communications data. DUMBTERM simply transmits data received from the keyboard and displays data received from the communications link; the



only processing involves filtering of line feed/carriage return codes. The program's four major structural blocks are as follows:

The *initialization* block installs the interrupt service routine, sets up the communications protocol, and enables the RS232 interrupt by reprogramming the 8259 and the communications chip on the asynch card.

The interrupt service routine is entered whenever the asynch card signals, via an interrupt, that it has data ready. The service routine gets the data from the card and stuffs it into a received data buffer.

The *data transmit* block checks for keyboard activity and transmits any characters found.

The *data receive* block checks the received data buffer and displays any characters found there.

Functionally, the program is simple: after initialization, it goes into a loop, alternately checking for keyboard activity and data received from the communications link. When a character is received from the keyboard, DUMBTERM outputs it to the RS232 card. After each keyboard scan, DUMBTERM looks at the received data buffer; if it is not empty, the first available character is retrieved and displayed.

As stated, the unique feature of DUMBTERM is that the RS232 input function is truly interrupt-driven. Nowhere in the program will you find a direct call to any RS232 input services. When the asynch card has assembled a byte of data from the bits

f last month's article can be thought of as time in the classroom, this month's is the field trip. As with most field trips, it helps if you bring along your field guide, in this case the IBM Technical Reference.

arriving through the modem, it generates a maskable interrupt; the interrupt service routine obtains the byte from the card and places it into a buffer, allowing the program mainline to process incoming data at its leisure. In this way, the mainline can initiate disk and printer I/O or perform any other type of time-consuming processing without losing incoming data.

Observant PC users will notice that this technique is functionally

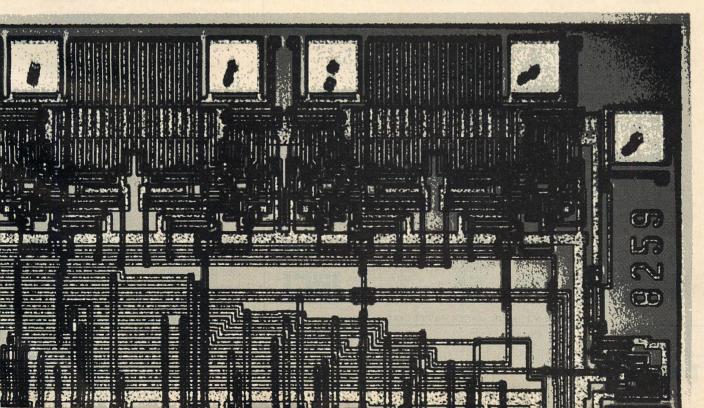
identical to the computer's keyboard handling. System and applications programs obtain keyboard data by watching BIOS's keyboard buffer and retrieving any characters placed there by the keyboard's interrupt service routine. That's why type-ahead works so well in the PC. Users of older machines like the Apple and the TRS-80 will remember lost keyboard data during disk I/O: these machines use polling rather than interrupts to read the keyboard.

It's apparent that the heart of the program, at least insofar as this article is concerned, is the interrupt service routine. And the key to the interrupt service routine is setting up the interrupt system so that the asynch card can generate an interrupt when it has data. In order to do that, it will be necessary to perform two basic tasks of initialization: First, we must enable the asynch interrupt at the system level, and second, we must set up the card to generate interrupts.

ENABLING IRQ4

This is the easy part. The *Technical* Reference indicates that the commu-

Chris Dunford is an independent consultant specializing in financial applications and technical services for personal computers in business



nications card is tied to interrupt line IRQ4. That is, the card uses IRQ4 whenever it wishes to request interrupt servicing. All that's necessary at this point is to enable IRQ4.

On power-up, the PC's BIOS masks all interrupts except IRQ0 (system timer), IRQ1 (keyboard), and IRQ6 (diskette adapter). In order to

enable IRQ4 from the asynch card, we have to alter the bit mask in the 8259's Interrupt Mask Register, replacing the one in bit 4 with a zero. The following code will do the trick:

IN AL,21H AND AL,11101111B OUT 21H,AL The first instruction reads the current contents of the IMR; the second instruction clears the mask for IRQ4 while retaining all other masks, and the final instruction sends the new IMR contents back to the 8259.

he 8250 is another special purpose microprocessor. It handles most of the housekeeping chores involved in communications, monitoring the status of the modem and communications line, assembling incoming bits into bytes and vice versa, adding start, stop, and parity bits, and more.

ENABLING ASYNCH INTERRUPTS

Having enabled IRQ4, we must now set up the asynch card to generate interrupts when it has data ready; for that, it will be necessary to know just a little bit about how the card works.

As noted in the *Technical Reference*'s description of the Asynchronous Communications Adapter, the heart of the board is a chip called the "INS8250 Asynchronous Communications Element or functional equivalent," or the 8250, for short.

The 8250 is another special purpose microprocessor. It handles most of the housekeeping chores involved in communications, monitoring the status of the modem and communications line, assembling incoming bits into bytes and vice versa, adding start, stop, and parity bits, and more.

One thing the 8250 does is to generate interrupts on the occurrence of any of four events. One of these is the *data ready* condition; in other words, the 8250 can generate an interrupt when it has assembled a complete byte of data from the bits arriving through the modem. As initial-

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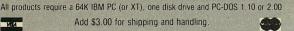
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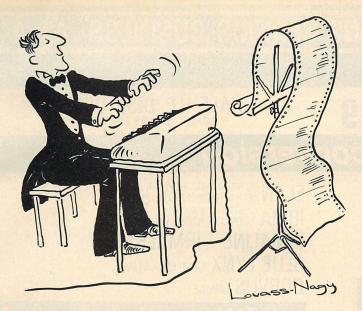
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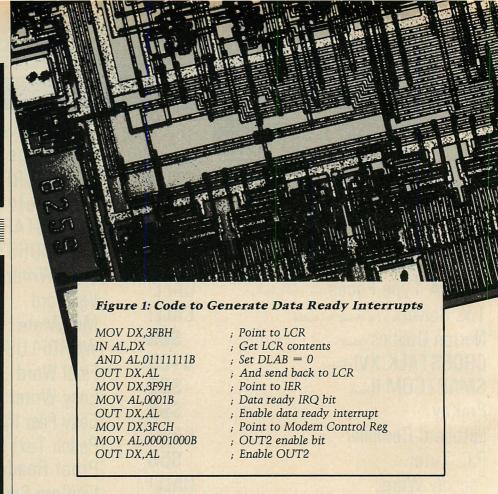
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ized by the BIOS, however, 8250 interrupts are disabled, so there is a little 8250 programming to be done.

The 8250 is programmed via several 8-bit internal registers. The most important of these for our purposes is the Interrupt Enable Register (IER), which has an enable flag for each of the four interrupts the chip is capable of generating (the other three are transmit buffer empty, line status change, and modem status change). The PC's BIOS has disabled all of these interrupts. To enable the data ready interrupt, the program must place a 1 in bit 0 of the IER. Note that this is the reverse of the convention in the 8259: There, a 1 disables an interrupt; here, a 1 enables it. That's because the 8259 has an Interrupt Mask Register, and the 8250 has an Interrupt Enable Register. This is a curious piece of design by Intel.

There's one other matter to be attended to: a signal from the 8250 called OUT2. This is essentially a software-controllable auxiliary signal from the chip; it can be used for whatever purpose the hardware designer wants. On the PC, OUT2 happens to be attached to the interrupt

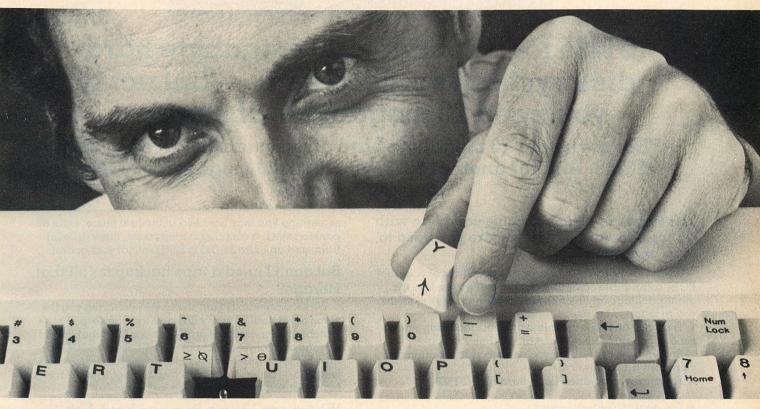
line from the 8250. In order for interrupts to be enabled, OUT2 must also be enabled. The *Technical Reference* (at least the old version) indicates that, to enable OUT2, bit 3 of the 8250's Modem Control Register must be set to 0. In fact, it must be set to 1.

Like the 8259, the 8250 is addressed as an I/O device. The PC's first asynch card occupies a block of ports beginning at 3F8H; the IER is located at 3F9H. There's one trick to sending data to some of the 8250's registers, though: ports 3F8H and 3F9H actually access several different registers, depending on the status of bit 7 of the 8250 register called the Line Control Register. This bit is called the DLAB (Divisor Latch Access Bit), for reasons that are irrelevant here. (See the Technical Reference for complete information on the 8250.) Suffice it to say that DLAB must be zero for all of the programming we will do. The Line Control Register is at port 3FBH; the complete code to tell the 8250 to generate data ready interrupts is shown in figure 1.

After execution of this code fragment, asynchronous communications interrupts are fully enabled. When

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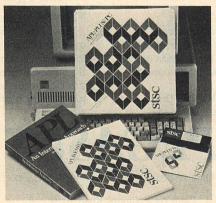
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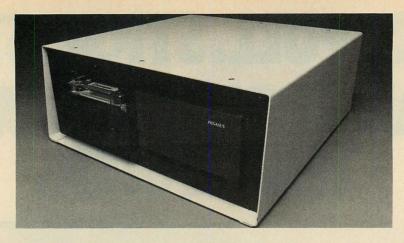
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the 8250 has assembled a byte of data from incoming bits, the following sequence occurs:

- 1. The 8250 requests an interrupt by sending a signal on IRO4.
- 2. The 8259 interrupt controller senses the IRO4 signal. On examining the Interrupt Mask Register. the 8259 finds that IRO4 is not masked, so it signals an interrupt to the 8088 via the INTR line (assuming no higher priority interrupts are pending or in service).
- 3. If interrupts are enabled, the 8088 acknowledges the interrupt request by sending a signal on INTA.
- 4. The 8259 places the interrupt type code on the data bus for the 8088's use. This code will be OCH: the IRQ number (4) plus the initialized base (8).
- 5. The 8088 disables interrupts, pushes the flags and CS:IP onto the stack, and jumps to the routine whose address is contained in the interrupt vector table for a type OCH interrupt.

Naturally, that means we'll have to have an interrupt vector ready for INT OCH when the 8250 interrupts. The best way to set an interrupt vector is via DOS function 25H. An example of vector setting is in the terminal emulator program.

One important note regarding communications under this scheme: There will be a problem using the standard BIOS RS232 support services. In the process of reading data from, or writing data to, the asynch card, the BIOS "turns off" OUT2. This means that the interrupts will be disabled again. Thus, any program using interrupt-driven communications will be forced to either have its own internal RS232 support or to re-enable OUT2 every time it requests BIOS service. I have chosen to include my own RS232 drivers in the sample program. The support is virtually identical to the BIOS support, except that it doesn't disable OUT2, and it doesn't check some of the status signals when it reads from the RS232.

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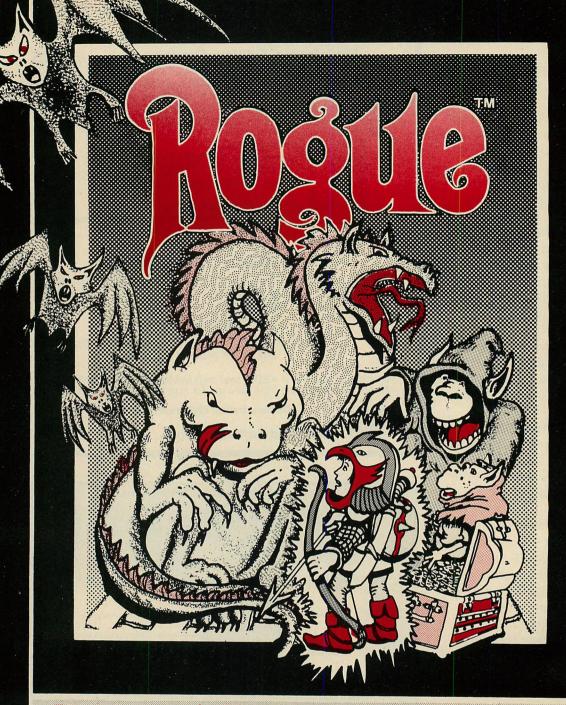
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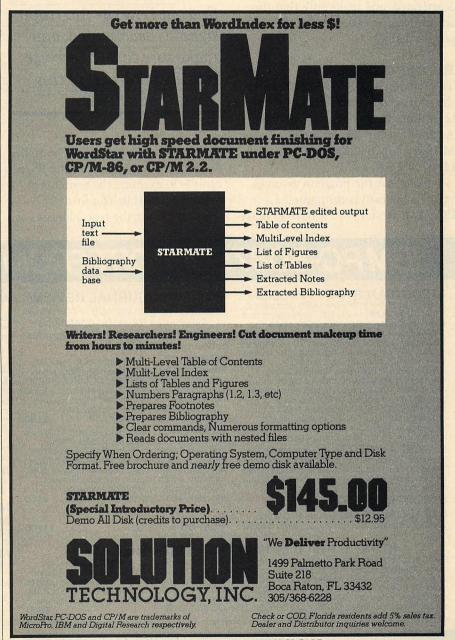
Now that DUMBTERM has gained control of the machine on an interrupt, what should the interrupt service routine do? In DUMBTERM's case, the routine will be fairly simple, but let's look at some general rules for interrupt servicing:

- Try to keep the routine short. About the worst thing you can do is to start stacking up pending interrupts.
- Preserve the contents of any registers used. It's generally impossible to know what registers are significant to the interrupted program, so save them all. The exception is the flags register, the IRET instruction restores the old contents from the stack, so it needn't be saved.
- —Interrupts will be off when the service routine gets control. In general, they should be re-enabled immediately on entry; otherwise, all other maskable interrupts (system timer, keyboard, and diskette I/O) will be dead in the water. Leave interrupts off only in special cases, such as when you are using the 8259's modified polling mode.
- Normally, it will be impossible to use the stack or 8088 registers to pass information between the service routines and the main program. Memory locations should therefore be used for this purpose. - The service routine must signal to the 8259 when processing is complete. The actual EOI process was described last month; the cleanest way to code the end of an interrupt service routine is to disable interrupts (CLI), signal EOI, pop the registers, and IRET. The IRET will restore the interrupt enable flag to its status prior to the interrupt, so no STI is needed.
- —In some cases you must reset the interrupting device, or in some way signal to it that it has been serviced. This is distinct from the 8259's EOI sequence.

DUMBTERM's interrupt service routine simply obtains the incoming byte from the RS232 card, stores it in a buffer, signals EOI to the 8259, and returns.

The only aspect of particular interest regarding DUMBTERM's interrupt servicing pertains to the last

item mentioned above: signalling to the interrupting device that it has been serviced. The service routine will signal EOI to the 8259, letting it know that interrupt processing is complete. But, as you may remember about edge triggering, the signal on IRQ4 must go low, then high again,



before the 8259's IRR bit 4 will be set again. In other words, the interrupt controller won't accept any more interrupts from the asynch card until after the IRO4 line has gone inactive. The EOI signal will NOT do this. How is IRQ4 turned off? Simple: The act of reading the data from the 8250 clears the data ready interrupt automatically. In developing service routines for other devices, remember to find out how the interrupt signal is deactivated, and make sure that the service routine takes care of this important action.

RUNNING DUMBTERM

To prepare DUMBTERM, just enter the source code from listing 1 (comment lines are not entered, of course). Assemble using the command MASM DUMBTERM and link with LINK DUMBTERM.

Note that the program assumes your RS232 card is configured as COM1. If it isn't, you'll have to make

a few adjustments. For one thing, some cards use IRQ3 (rather than IRQ4) for COM2. Also, COM2's 8250 registers begin at 2F8H rather than 3F8H. I have, by the way, hard-coded these addresses into DUMBTERMnot a good practice, but it made the

n developing service routines for other devices, remember to find out how the interrupt signal is deactivated, and make sure that the service routine takes care of this important action.

interrupt-enabling clearer. The right way to get the addresses of the RS232 cards is to examine the contents of memory at 40H:0. The first two words there are the base addresses of

COM1 and COM2, respectively.

After assembly/link, fire up your modem and execute the program by typing DUMBTERM from the DOS prompt. The program will display the message ONLINE when it has loaded and initialized. From that point, anything typed on the keyboard (except ESC) will be sent to the RS232 port, and anything received from the port will be echoed to the screen. Dial up your favorite bulletin board using the method needed by your modem (SmartModem users can type ATD and the number as usual), and you'll be connected. Error indications may appear as follows:

<S> There's a problem sending data. The modem may not be turned on.

<R>> There's a problem receiving data. If there are many of these, the parity or another comm parameter is probably wrong. The program is hard-coded for 300

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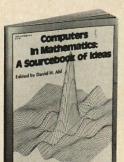
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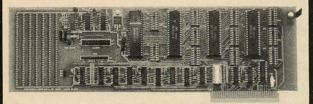
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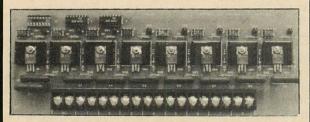
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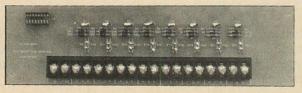
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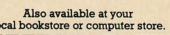
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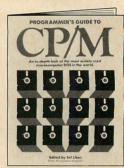
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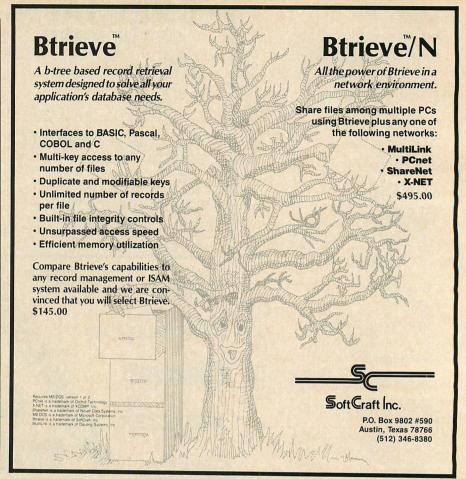
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^{*3}Com Corp. in March Systems & Software, pg. 118
**3Com Corp. in March Systems & Software, pg. 119

baud, 8 data, 1 stop, no parity. There are some comments in listing 2 that indicate how to change the parameters.

 The buffer has overflowed. This is unlikely to happen.

To end the program, hit the Esc key.

SOME FINAL THOUGHTS

Now that you can make the PC's interrupt system jump through the hoop on command, what else can you do with interrupts? It depends on what kind of peripheral cards are installed in your machine, and what their interrupt capabilities are.

Sticking to the communications area, one idea that comes to mind is a background host program. I've heard quite a few people say that they would like to run a bulletin board service, but that they can't/won't dedicate their PCs to it. How about a host program that sits in background.

waiting for an interrupt from the modem, indicating an incoming call? It certainly seems feasible, if tricky.

Another possibility is interruptdriven print spooling. The Technical Reference indicates that the parallel printer adapter is capable of generating an interrupt using IRQ7, whenever the printer makes the transition

hat else can you do with Interrupts? It depends on what kind of peripheral cards are installed in your machine, and what their interrupt capabilities

from busy to idle. This would make for an efficient spooler, particularly compared to some of the other spooling schemes around.

Finally, I should note that programming the 8259 allows you to selectively enable/disable interrupts, as opposed to the blanket effect of STI/ CLI instructions. You want to disable the clock interrupt? CLI won't do it, unless you also want a dead keyboard and inactive disk drives. (Not to mention your new background host program that won't answer the phone!) But you certainly can disable IRQ0 while leaving the rest alone.

REFERENCE

1. IBM Personal Computer Technical Reference. IBM Corporation, P.O. Box 1328, Boca Raton, Fl 33432.

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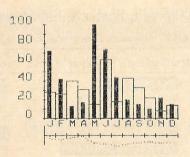
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LISTING 1 DUMBTERM SOURCE CODE

```
DUMBTERM
; Author:
                CJ Dunford
                09/12/83
: Rev.:
                DUMBTERM. ASM
                DUMBTERM. OBJ
; Object:
                 DUMBTERM. EXE
 Code:
: 0/S:
                 PCDOS 1.1, 2.0
; Note that the program assumes that the RS232 port is configured
; as COM1. It will have to be modified to use COM2. Also,
; the communications parameters are set as 300 baud, 7 data bits,
; 1 stop bit, even parity. This can be changed--see the INIT; procedure. DUMBTERM will easily keep up with 1200 baud or more.
  Assembly/link:
   Assemble: MASM dumbterm;
   Link: LINK dumbterm;
  (from DOS prompt): DUMBTERM
   EQUATES & DEFINITIONS
  * * * * * * * * * * * * * * *
  ---- Define size of buffer
                                            : 4K--can be adjusted
BUFSIZE
              equ
: ---- ASCII codes
                                            ; Line feed
               equ
                 equ
                          ODH
                                            ; Carriage return
              equ
                                            ; Escape
: ---- BIOS calls
```

RS232	equ	14H 16H	; RS232 service ; Keyboard service
bd_io	equ	1011	; Keyboard Service
IN	\$8250 ACE re	egisters	
THR eq	ш 3F8H		; Trans holding register (write)
RBR eq	u 3F8H		; Receiver buffer register (read)
IER eq	u 3F9H		; Interrupt enable register
_CR eq	u 3FBH		; Line control register.
			; Bit 7 of LCR is "DLAB". DLAB must
			; be zero to access THR, RBR, IER.
MCR eq	u 3FCH		; Modem control register
LSR eq	u 3FDH		; Line status register
MSR eq	u 3FEH		; Modem status register
	nm parameter	dofiniti	
	IBM Tech Re		
CONTRACTOR STATEMENT AND ADDRESS OF THE PARTY OF THE PART	INIT for us	BANKS BANKS BANKS BANKS BANKS	20
, see proc			
			2 stophits:1 wordhits:2
			2, stopbits:1, wordbits:2
commparm r	ecord baud:		2, stopbits:1, wordbits:2
commparm r	ecord baud:3	3, parity:	2, stopbits:1, wordbits:2
commparm r ; Baud rat 3110	ecord baud:3 es equ	3, parity: 000B	2, stopbits:1, wordbits:2
commparm r ; Baud rat 3110 3150	ecord baud:3 es equ equ	000B 001B	2, stopbits:1, wordbits:2
commparm r ; Baud rat 3110 3150 3300	ecord baud:3 es equ equ equ	000B 001B 010B	2, stopbits:1, wordbits:2
; Baud rat 3110 3150 3300 8600	ecord baud:: es equ equ equ equ	000B 001B	2, stopbits:1, wordbits:2
; Baud rat 3110 3150 3300 3600 B1200	ecord baud: es equ equ equ equ equ	000B 001B 010B 011B	2, stopbits:1, wordbits:2
; Baud rat 3110 3150 3300 8600	ecord baud:: es equ equ equ equ	000B 001B 010B 011B 100B	2, stopbits:1, wordbits:2
; Baud rat 3110 3150 3300 3600 B1200 B2400	ecord baud: S es equ equ equ equ equ equ	000B 001B 010B 011B 100B 101B	2, stopbits:1, wordbits:2
; Baud rat 3110 3150 3300 3600 B1200 B2400 B4800	ecord baud: a es equ	000B 001B 010B 011B 100B 101B	2, stopbits:1, wordbits:2
; Baud rat 3110 3150 3300 3600 B1200 B2400 B4800	ecord baud: a es equ	000B 001B 010B 011B 100B 101B	2, stopbits:1, wordbits:2
; Baud rat 3110 3150 3300 3600 81200 82400 84800 89600	ecord baud: a es equ	000B 001B 010B 011B 100B 101B	2, stopbits:1, wordbits:2
commparm r ; Baud rat 3110 3150 3300 3600 81200 82400 84800 89600 ; Parity	es equ	000B 001B 010B 011B 100B 101B 110B 111B	2, stopbits:1, wordbits:2
commparm r ; Baud rat 3110 3150 3300 3600 81200 82400 84800 89600 ; Parity	es equ	000B 001B 010B 011B 100B 101B 110B 111B	2, stopbits:1, wordbits:2
commparm r ; Baud rat 3110 3150 3300 3600 881200 82400 84800 89600 ; Parity no parity	es equ	000B 001B 010B 011B 100B 101B 110B 111B	2, stopbits:1, wordbits:2
commparm r ; Baud rat 3110 3150 3300 3600 881200 82400 84800 89600 ; Parity no parity	es equ	000B 001B 010B 011B 100B 101B 110B 111B	2, stopbits:1, wordbits:2
; Baud rat 3110 3150 3300 3300 3400 32400 34400 34800 39600 ; Parity ood_parity even_parit	es equ	000B 001B 010B 011B 100B 101B 110B 111B	2, stopbits:1, wordbits:2

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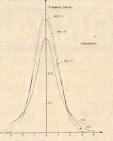
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```
; Data bits
data7
data8
                equ
                         11B
; * * * * * * * * * * * * * *
; MACROS ; * * * * * * * * * * * * *
@bioscall MACRO call num, parm
;; Generates an 'INT call num', with parm in AH
       IFNB <parm>
          mov ah, parm
        ENDIF
        int call num
        ENDM
@doscall MACRO function,parm
;; Generates a DOS function call with parm in AL
        IFNB <parm>
         mov al, parm
        ENDIF
        Obioscall 21H, function
        endm
    DATA & STACK SEGMENTS
*********
data segment para public 'data'
; ---- The string section
sgreeting db '--- ONLINE ---',CR,LF,'$'
sgoodbye
                db
                        CR,LF,'--- OFFLINE ---',CR,LF,'$'
                    '<R>$' ; RS232 receive error
'<S>$' ; RS232 send error
'<B>$' ; Receive buffer overflow error
serr1
               db
serr2
                db
serr3
                db
```

```
: ---- Flags
brcv_err db 0 ; Nonzero on RS232 receive error
boverflow
              db 0
db 0
                          ; Nonzero on buffer overflow
bdoneflag
                              : Nonzero after ESC from kbd
; ---- Received data buffer and associated pointers
; >> Buffer is empty if head pointer = tail pointer
wbufhead dw buffer ; Pointer to head of buffer
                   buffer ; Pointer to tail of buffer
whuftail
               dw
buffer
               db
                      BUFSIZE dup (?)
hufend
               eau $
data ends
: ---- Stack
stack segment para stack 'stack'
      db
              256 dup (?)
stack ends
; * * * * * * * * * * * *
     PROGRAM MAINLINE
code segment para public 'code'
       assume cs:code, ds:data, ss:stack
main
      proc far
: ----- Initialize
       push ds
                             ; Set up long ret to DOS
       sub ax, ax
      push ax
       call init
                              ; Rest of initialization
; ---- Main program loop
M100:
       call buffer check
                             ; Check RS232 bfr. Display if not empty
       call kb check
                             ; Check kbd. Send to RS232.
       test bdoneflag,OFFH
                             ; Non-zero if done
       jz M100
                              ; Loop till ESC received
```

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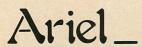
```
; ---- ESC received. Clean up interrupt & exit
      call cleanup ; Clean up
                               ; Return to DOS
       endp
; * * * * * * * * * * * * * * *
 PRIMARY BLOCKS
; Program initialization:
   -- Set up RS232
   -- Set up vector for RS232 interrupt (INT OCH)
    -- Enable IRQ4
   -- Enable RS232 interrupt on data ready
; NOTE: The communications parameters are established
; here. To use other parameters, change the parameters
; in the 'mov al, commparm' statement below. See the
; communications parameters record definition (above)
; for the correct abbreviations.
: Examples:
   1200,N,8,1: mov al,commparm <B1200,no_parity,stop1,data8>
   4800,0,7,2: mov al,commparm <84800,odd_parity,stop2,data7>
init proc near
; ---- Initialize RS232: 300,8,N,1
                                      ; COM1
      mov dx,0
       mov al,commparm <B300,no_parity,stop1,data8>
       Objectall RS232.0
; ---- Set up INT x'OC' for IRQ4
       cli
                                      ; Interrupts off during setup
       push ds
       mov dx,offset ISR
                                      ; Point to RS232 ISR in DS:DX
       push cs
```

```
pop ds
       @doscall 25H,OCH
                                       ; Set int vctr for IRQ4
       pop ds
                                        ; Restore DS
 ---- Enable IRQ4 on 8259 interrupt controller
       in al, 21H
                                       ; Get current masks
       and al,11101111B
                                       ; Reset IRQ4 mask
       out 21H, a1
                                       ; And restore to IMR
; ---- Enable 8250 data ready interrupt
       mov dx.LCR
                                       ; DX ==> LCR
       in al,dx
                                       ; Reset DLAB for IER access
       and al,01111111B
       out dx, al
       mov dx, IER
                                       ; Address IER
       mov al.00000001B
                                       ; Enable 'data-ready' interrupt
       out dx.al
 ---- Enable OUT2 on 8250
       mov dx,MCR
                                       ; Address MCR
       mov al,00001000B
                                       ; Enable OUT2
       out dx, al
       sti
; ---- Display greeting & return
       mov ax,data
                                       ; Establish data seg address
       mov ds,ax
       mov dx, offset sgreeting
                                       ; Point to greeting
       call strdisp
                                       ; Display it
       ret
init endp
; ---- BUFFER CHECK -----
; RS232 buffer check
; This block checks the received data buffer.
; It functions as follows:
; IF the RS232 input buffer is not empty
```



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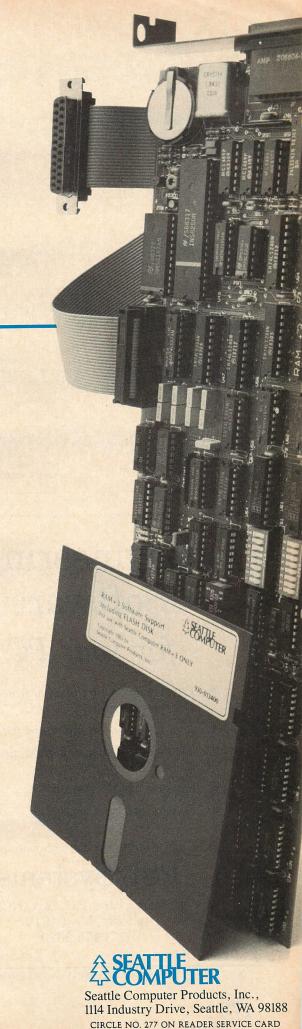
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PC INTERRUPTS

```
Get the first character
     Display the character
     Update buffer pointer
; IF the RS232 receive error flag is nonzero
     Display an error indicator
; IF the buffer overflow flag is nonzero
    Display an error indicator
; No requirement
: Exit:
; AX, BX, DX destroyed
buffer check proc near
; ---- Check buffer status
       mov bx, wbufhead
                                        ; Buffer head pointer
                                        ; Buffer empty if head = tail
       je BC100
                                        ; Jump if empty
 ---- Something in buffer--get 1st char, fix pointers
                                        ; Get the char
                                        ; Bump buffer head pointer
; ---- Display character received. Filter CR/LF
                                        ; Is it a line feed?
; Skip display if yes
       cmp al, LF
       ie BC100
       call chdisp
                                        ; Display if no
       cmp al,CR
                                       ; Is it a CR?
       jne BC100
                                        ; Jump if not
                                        ; Send LF if yes
       call chdisp
---- Test RS232 receive status; display errors
       test brcv_err,OFFH
                                       ; Flag nonzero if errors
       jz BC200
                                        ; Jump if no errors
```

```
; Point to error msg
        call strdisp
        mov.brcv_err,0
                                       ; Clear error flag
 ; ---- Test for buffer overflow; display errors
        test boverflow, OFFH
        jz BC300
                                    ; Z if no overflow
        mov boverflow,0
                                       ; Clear the flag
        mov dx,offset serr3
                                       ; Point to error msg
        call strdisp
                                       ; And display
BC300:
buffer check endp
; Check keyboard. Functions as follows:
; Check the keyboard status
; IF a character is available
   IF the character is ESC
      set the 'done' flag
   ELSE
      send it to RS232 and watch for errors
; Note that this routine does not echo the KB characters
; to the display. Display occurs only when the characters
; are echoed back by the remote terminal.
; Entry:
  No requirement
; Exit.
; AX, DX destroyed
                 -----
kb check proc near
; ---- Poll keyboard, check chars received
```

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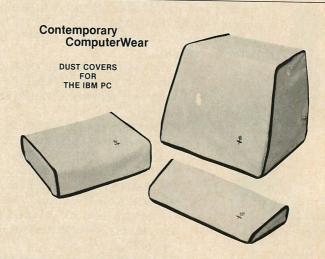
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PC INTERRUPTS

```
call kb_poll
                                          ; Poll the keyboard
         jz KBC900
                                          ; Kbd clear, exit
         cmp al.ESC
                                          ; Escape?
         ine KBC100
                                          ; No, continue
         mov bdoneflag.OFFH
                                          ; Yes, set termination flag
         imp short KBC900
 ; ---- Send the received char, watch for errors
KBC100:
        call RS232 out
                                          ; Send it
         test ah.80H
                                          ; Time out?
         jz KBC900
                                          ; No. sent OK
        mov dx,offset serr2
                                          ; Point to error msg
        call strdisp
                                          ; And display it
KRC900.
kb check endp
; ---- ISR -----
 This is the RS232 interrupt service routine. It
; is entered whenever the RS232 port interrupts on a
  'data ready' condition. The routine simply reads
; the data from the asynch chip and stuffs it in the
; buffer. Note that the process of reading the
 received data register in the 8250 clears IRQ4.
; However, the 8259 must be told specifically that the
; interrupt service is complete.
; This replaces the function 2 of BIOS interrupt 14\mathrm{H}
; (receive a character over the comm line). Since
; it cannot return errors in a register, it puts the
; error marker in memory at 'brcv_err'. The error
; flag is 'sticky'--a successful read will NOT clear a
; prior error indication. This allows the program
; mainline to examine the error status at its
 leisure. Error bits are the same as in RS2320UT,
; above, except that ONLY the error bits are set.
; and bit 7 is not used (always 0). In other words,
```

: The ISP will set the a	conflant flam (f. 1)
; should overflow. Shou	verflow flag if the buffer
;	
ISR proc near	
sti	; Allow other interrupts
push ax	; Save all regs used
push bx	
push dx	
push si	
push ds	
; Establish data ad	dressability
mov ax,data	
mov ds,ax	
; Get error bits	
mov dx,LSR	; Base address of RS232
in al,dx	; Get status
and al,00011110B	; Mask non-error bits
jz ISR010	; Skip error set if OK
mov brcv_err,al	; Set error indicator
; Get incoming chara	actor and huffon it
ISR010:	asset and parter it
mov dx,RBR	; Receiver buffer
in al,dx	; Get input character
mov bx,wbuftail	; Buffer input pointer
mov si,bx	; Save pointer b4 increment
call incptr	; Bump input pointer
cmp bx,wbufhead	; Overflow if head = tail
je ISRO20	; Overflow
mov [si],al	; No overflow, save char in buffer
mov wbuftail,bx	; And new input pointer
jmp short ISR999	
ISR020:	
mov boverflow, OFFH	; Set overflow flag

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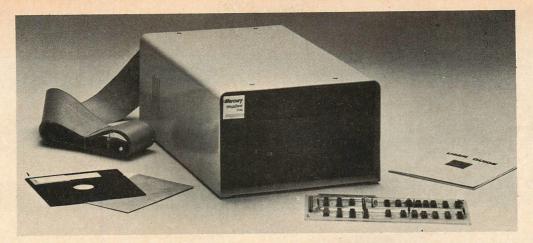
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PC INTERRUPTS

```
-- Signal end of interrupt to 8259
ISR999:
        cli
        mov al 20H
                               ; Non-specific EOI
        out 20H, al
                               : Send it
; ---- Restore regs & return. IRET reenables interrupts
        pop ds
        pop dx
        pop bx
        pop ax
        iret
ISR endp
; ---- CLEANUP -----
; End of program housekeeping
  -- Disable IRQ4
  -- Disable 8250 interrupts
; -- Disable OUT2
   -- Display offline message
cleanup proc near
; ---- Disable IRQ4 on 8259
        in a1,21H
                                      ; IMR
       or al,00010000B
                                     ; Mask bit 4--IRQ4
       out 21H, al
; ---- Disable 8250 data ready interrupt
       mov dx,LCR
                                     ; DX ==> LCR
       in al, dx
                                     ; Reset DLAB for IER access
       and a1,01111111B
       out dx.al
       mov dx. IER
                                     ; Address IER
       mov al.0
                                      ; Disable all 8250 interrupts
       out dx, al
```

```
---- Disable OUT2 on 8250
        mov dx,MCR
                                       : Address MCR
        mov al.0
                                       ; Disable OUT2
        out dx, al
        sti
 ; ---- Display bye-bye
     mov dx,offset sgoodbye
        call strdisp
cleanup endp
; * * * * * * * * * * * * * * *
  1/0 & GENERAL SUBROUTINES
; Set/reset I flag on keyboard buffer status.
; No requirements
; I = 1 if nothing available
; Z = 0 if char available from kbd
; IF Z = 0
   AL = char
     AH = scan code
; Other regs preserved
kb poll proc near
       Obioscall kbd_io,1
                            ; Poll KB. Sets Z flag if KB bfr empty
       jz KB999
                             ; Nothing there
       pushf
                               ; Save flag status
       Obioscall kbd io,0
                            ; Something there; get it
       popf
KB999:
kb poll endp
```



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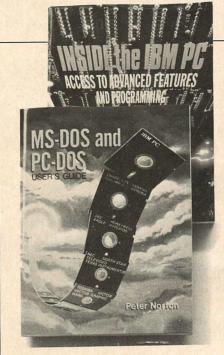
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Authoritative

The authority, Peter Norton, takes a stand on the Microsoft Disk Operating system and has created a compendium of information on DOS unavailable elsewhere. Over sixty computers use MS-DOS or a related version, so this book will serve as a welcome reference for the PC at home or in the office.

With handholding examples and explanations of MS-DOS, Peter Norton includes chapters on Fundamentals of DOS Commands, Getting the Most of DOS Editing Keys, What You Need to Know about Diskettes and File Formats Programming Languages, Batch Files, and Copy Protection. Norton gives expert advice on copy protection and software selection. For both the novice and the expert, he provides a glossary and a summary of commands for easy reference.

Peter Norton has earned his reputation as the authority on the IBM PC resulting from years in the field, articles in major magazines, lectures, interviews and consulting work. The expertise gleaned by Norton appears within the pages of his two books and benefits the reader and his PC.



"MS-DOS and PC-DOS: User's Guide" Peter Norton 1983/250pp/paper/ISBN 0-89303-645-5/D6455-2/\$15.95

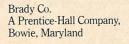
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The book that has become the final companion to the machine, "Inside the IBM PC: Access to Advanced Features and Programming" illuminates the inner workings of the machine while demonstrating how both beginning and advanced programmers can take advantage of the many features offered by the PC. Norton also explains how the ROM is allocated for BASIC and BIOS. He explores the RAM for functions like the monochrome and color monitor displays and shows how the assembler can be integrated into Pascal and BASIC to access more power from the IBM PC.

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PC INTERRUPTS

```
--- RS232 out -
; RS232 output routine
; This routine sends one character to the RS232 port.
; It replaces function 1 of BIOS int 14H. This is
; necessary because BIOS will disable the RS232
; interrupt (by disabling OUT2) every time it is
  AL = character to be transmitted
; Exit:
; AH = send status
  Bit 7 = 1 if RS232 timeout occurred
    IF bit 7 = 0
       bit 6: trans shift register empty
       bit 5: trans holding register empty
       bit 4: break detect
       bit 3: framing error
       bit 2: parity error
       bit 1: overrun error
       bit 0: data ready
  Other regs preserved
R$232 out proc near
       push bx
                                ; Save regs used
       push cx
       push dx
; ---- Set up RS232
       mov bl.al
                               ; Save char to BL temporarily
       mov dx MCR
                                ; Modem Control Register
       mov al.00001011B
                               ; OUT2, DTR, RTS
       out dx.al
       sub cx.cx
                               ; Initialize timeout count
       mov dx ,MSR
                               ; Modem Status Register
 ---- Wait for DSR
```

	in al,dx	
	test al,20H	; Data set ready?
	jnz RS150	; Yes
	100p RS100	; No, retry till timeout
	mov ah,80H	; Set timeout
	jmp short RSXIT	; And quit
;	Wait for CTS	
RS150:		
	sub cx,cx	; Another timeout count
RS200:		
	in al,dx	
	test al,10H	; Clear to send?
	jnz RS250	; Yes
	100p RS200	; No, loop till timeout
	mov ah,80H	; Timeout, set flag
	jmp short RSXIT	; And quit
;	Wait for THRE	
RS250:		
	mov dx,LSR	; Line Status Register
	sub cx,cx	; Yet another timeout count
RS300:		
	in al,dx	; LSR status
	test al,20H	; Transmit holding reg empty?
	jnz RS350	; Yes
	loop RS300	; No, loop till timeout
	mov ah,80H	; Timeout, set flag
	jmp short RSXIT	
	Get line status, sen	d chan
RS350:	det Time Status, Sen	d that
	mov ah,al	; Get line status for return
	and ah,011111118	: Mask out bit 7
	mov al.bl	; Restore char to AL
	mov dx, THR	; Trasnmit holding register
	out dx, al	; Output it to RS232
RSXIT:	out anjui	, output it to k3232
	pop dx	
	pop cx	
	Pop CV	

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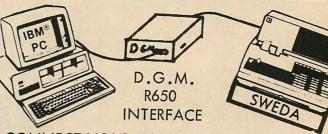
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PC INTERRUPTS

```
DOD bx
RS232 out endp
; ---- CHDISP -----
; Display the character in AL on the \ensuremath{\mathsf{CRT}}
; Entry:
; AL = char
: Exit:
; All regs restored
chdisp proc near
       push ax
       push dx
       mov dl.al
       @doscall 2
       pop dx
       pop ax
       ret
chdisp endp
; ---- STRDISP -----
; Display the string at DS:DX on the CRT
; Entry:
: DS:DX ==> string
; Exit:
: All reas restored
strdisp proc near
       nush ax
       @doscall 9
       pop ax
       ret
strdisp endo
```

```
; Increment the buffer pointer in reg BX.
; If the pointer goes beyond the end of the
; buffer, wrap around to start.
; BX = buffer pointer
; Exit:
; BX = advanced buffer pointer
  Other regs restored
incptr proc near
                                       : Bump pointer
        cmp bx,offset bufend
                                       ; Past end?
        jne IP100
                                        ; Jump if not
       mov bx,offset buffer
                                        : Else point to start
IP100:
incptr endp
code ends
       end main
```

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The Truth about BASIC

Logical operators that masquerade as arithmetic operators



J. EDWARD VOLKSTORF, JR.

Philosophers have long argued the question, What is truth? For users of BASIC on the IBM PC, the answer is simply -1, with false being 0. The significance of this "revelation" is that logical operators such as <, >, and = can be used like the more typical arithmetic operators in the creation of mathematical expressions.

The reasons for wanting to use logical operators in this way are many. For example, a series of individual IF/THEN statements on separate lines can be combined into a single line of BASIC code for saving of both memory space and through-put. This tech note will illustrate how to create such expressions and provide some examples of their use.

As an illustration of the general concept consider the statement:

PRINT X<> 0

which will cause a-1 to print if X is some non-zero value; a 0 will be printed otherwise. It is an easy extension to use the expression to set a flag based on the value of X as in

LET NON.ZERO = X <> 0

The flag might be used throughout a program in expressions such as

IF NON.ZERO THEN ... ELSE ...

To make use of the actual value of the logical expression, it is necessary to combine that expression with other operators.

Consider a FOR/NEXT loop that tallies the number of non-zero values in an array:

100 TNZ=0 110 FOR I=1 TO N:

IF X(I)<>0 THEN TNT=TNZ+1 120 NEXT I

As an alternative consider the following:

100 TNZ=0 110 FOR I=1 TO N: TNZ=TNZ-(X(I)<>0): NEXT

The expression (X(I) <> 0) evaluates to either a 0 or -1 and is negated by the minus sign to 0 or +1. Thus 0 is added to TNZ for false cases and 1 for the true situations, which accomplishes the goal of tallying the non-zero entries. No doubt it is rather curious to see a subtraction operation used to "add-up" values in a counter. After using these expressions for a while you will become accustomed to this oddity.

Another variation of the above expressions can be used to control whether or not a counter is incremented (or decremented). Let R be a row value for locating text on the screen. If R is less than 25 then it can be incremented:

IF R < 25 THEN R = R + 1

This can also be coded

$$R=R-(R<25)$$

Likewise for decrementing R, the statement

IF R > 1 THEN R = R - 1

can be coded

$$R = R + (R > 1)$$

Note the use of the plus sign, which reverses the oddity noted earlier.

These logical expressions can be extended further to include other variables and constants. To deter-

mine the maximum of two values with the typical IF/THEN code, you might produce

IF A>B THEN MAX= A ELSE MAX=B

but an arithmetic expression can accomplish the same thing:

$$\mathbf{MAX} = \mathbf{A} - (\mathbf{B} > \mathbf{A})^* (\mathbf{B} - \mathbf{A})$$

Likewise, for determining the minimum we have

MIN = A + (A > B)*(A - B)

Although these two expressions do not save execution time (because additional arithmetic operators must be evaluated), they do allow the creation of functions such as

DEF FNMAX (A,B)= A-(B>A)*(B-A)

and.

DEF FNMIN(A,B) = A + (A>B)*(A-B)

that can decrease memory usage.

Another useful place for these types of expressions is in the extraction of sub-strings. For example, when time is printed, an AM or PM should follow if "non-military" time format is used. If the variable HRS is an hour in the 23-hour day, and TIM\$ represents the 12-hour time format, then the expression

TIM\$=TIM\$+" "+MID\$ ("PM AM", 4+(HR\$>11)*3,2)

will tack on the appropriate AM or PM value for the time given.

This type of string expression can also be used for adding an *s* at the end of a text message to indicate quantities other than one. If NFS is the number of files in your system

then the message

PRINT "You have"; NFS; "file"+LEFT\$("s",-(NFS<>1)

produces the singular form only when there is one file in the system, displaying the plural form for all other numbers of files.

The following FOR/NEXT loop converts lowercase text to uppercase, where TEXT\$ contains the characters to be converted.

100 FOR I=1 TO LEN (TEXT\$) 110 CODE=ASC (MID\$(TEXT\$, I)) 120 MID\$=ASC (CODE+(CODE>=97 AND CODE <= 122)*32) 130 NEXT

If a character is lower case, i.e., its ASCII code is between 97 and 122, then -32 is added to it, setting its value to the uppercase ASCII codes, which range from 65 to 90.

As such expressions become more involved and complex, they are harder to read and, ultimately, harder to maintain when changes to the software are required. An expression that seemed simple and elegant initially, might look incomprehensible after a few months. Consequently, when coding in this manner, use common sense and prudence.

Ed Volkstorf's company, New Venture Systems, produces educational administrative software. His book, Graphics Programming on the IBM Personal Computer, was published by Prentice-Hall.

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- 2. Date of filing: October 1, 1983
- 3. Frequency of issue: Bimonthly a. No. of issues published annually: 6 b. Annual subscription price: \$24.97
- Location of known office of publication: PC Tech Corp., The World Trade Center, Suite 211, Baltimore, Maryland 21202
- 5. Location of the headquarters or general business offices of the publisher: PC Tech Corp., The World Trade Center, Suite 211, Baltimore, Maryland
- 6. Names and complete addresses of the publisher, editor, and managing editor: Publisher: Jeff Weiner, One Park Avenue, New York, New York 10016; Editor: Will Fastie, The World Trade Center, Suite 211, Baltimore, Maryland 21202; Managing Editor: Marjory Spraycar, The World Trade Center, Suite 211, Baltimore, Maryland 21202.
- 7. Owner: PC Tech Corp., The World Trade Center, Suite 211, Baltimore, Maryland 21202; Ziff-Davis Publishing Company, One Park Avenue, New York, New York 10016.
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PCjr!

IBM's long-awaited Peanut, code-named "PCjr," was finally announced in November. The new personal computer, which has an entry price of only \$669, is the least expensive computer ever offered by the world's largest computer company.

IBM stated that the new PCjr would be targeted at



home, educational, and business users and is scheduled for availability this month through more than 1,000 authorized dealers, as well as through IBM's National Accounts and National Marketing divisions. IBM said that early supplies of PCjr might be limited and may not be sufficient to meet expected demand, although production rates are expected to rise throughout 1984.

The basic machine employs a single circuit card for the system logic and uses a 4.77MHz Intel 8088 processor, the 8259A, 8255A, and 8253-5 support chips, the

INS8250 LSI chip for the serial port and the Motorola 6845 chip for video display control. This is the same set of circuitry used by the PC. The system board also houses 64KB of RAM and 64KB of ROM; a speaker; an I/O expansion bus; interfaces for cassette, two joysticks, keyboard, composite video, and direct drive video; and expansion slots for memory, diskette, and modem expansions. Two slots for ROM program cartridges are provided and are accessible from the front of the system unit.

An enhanced model of PCjr, with a base price of \$1,269, includes an additional 64KB of RAM, extensions to the machine's graphics capabilities, and a dual-sided, double-density slim-line diskette drive that is capable of recording 360KB of information per diskette.

Both models sport a chiclet-style, 62-key keyboard that uses an infrared link to the system unit. The keyboard may be used up to 20 feet away from the computer and requires four AA batteries. If the infrared link is not desirable, such as when multiple PCjrs or other equipment are using infrared links, an optional keyboard cable (\$20) can be used.

The basic PCjr includes video graphics identical to those on the PC. When the memory/display option is present, additional graphics modes are available. In medium resolution, sixteen colors can be displayed at the same time. In high resolution, any four of the sixteen supported colors can be used. A new low resolution mode is also provided.

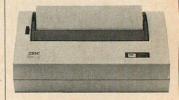
An extensive list of options includes a 300-baud built-in modem (\$199), joysticks (\$40 each), RF modulator (\$30), carrying case (\$60), and various attachment cables such as those for cassette (\$30) and serial (\$25).

The PCjr includes a 12month warranty and can be serviced by authorized dealers or by IBM. IBM will offer warranty extensions and service agreements; no prices or terms were announced.

Printer

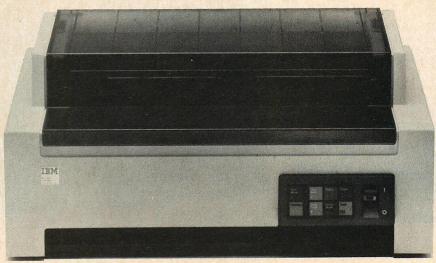
A new printer, called the IBM PC Compact Printer, was announced for the PCjr. Priced at \$175 and requiring an adapter costing \$40, the printer uses thermal technology and can print uni-directionally at 50 characters per second, with an estimated 25 cps throughput. Print modes include 80 characters per line at 10 characters per inch, 40 CPL at 5 CPI, 68 CPL at 8.75 CPI, and 136 CPL at 17.5 CPI. All points addressable graphics are supported. Heat sensitive paper up to 8.5" wide in rolls, sheets, or fan fold can be used in the Compact Printer.

The Compact Printer adapter is a serial EIA (modified RS-232C) port operating at 1200 bits per second. The data path to the printer is eight bits wide; buffering of 256 characters is provided. All 128 ASCII characters are supported in a total character set of 191 printable characters. In addition, a parallel printer adapter for the PCjr, priced at \$99, allows connection of the IBM Graphics Printer or similar printers. The printer adapter attaches to the right side of the system unit where the expansion bus is provided.



Software

The entry model of PCjr includes cassette BASIC in ROM. In addition, programs may be loaded into the machine via one of the two cartridge slots. Cartridge software includes PCjr BASIC (\$75) and four games (each



PC Color Printer

\$35): Crossfire, Mine Shaft, Mouser, and Scuba Venture.

In order to take full advantage of the enhanced model, the new release of IBM DOS,



priced at \$65, is required. DOS 2.1 was announced simultaneously for the IBM PC, XT, and PCjr and offers compatability of operation across all three machines.

An extensive list of software targeted at users in business (MultiPlan, PFS:File, VisiCalc, EasyWriter), the home (HomeWord, Home Budget), and schools (Arithmetic Games, Monster Math, LOGO) included many programs already available for the PC and modified for PCjr operation. PCjr-specific documentation includes a Guide to Operations, Technical Reference, BASIC Reference, and two new tutorial books: BA-SIC Made Easy for the IBM PCir and Hands-on BASIC for the IBM PCjr.

IBM expects a popular home configuration to be an enhanced model of PCjr with TV connector, the Compact Printer, DOS 2.1, and cartridge BASIC,—\$1,624 at IBM Product Centers.
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ALSO FROM IBM

IBM has announced a new, medium-speed, dot-matrix printer, called the **IBM Personal Computer Color Printer**, that features such capabilities as near-letter-quality printing, graphics, and color. The printer costs \$1,995.

Using a 9-wire, staggered printing element, the printer can produce text at 200 characters per second in its data processing mode, 110 to 120 cps in its so-called text quality mode, and 35 cps in its near-letter-quality (NLQ) mode. Printing is bidirectional except for the NLQ mode. In all modes, characters can be printed at 10, 12, or 17.1 characters per inch with fixed or proportional spacing. Line spacing can be set via switch to six or eight lines per inch. The character set includes the standard ASCII 96 character set. The printer produces true lower-case descenders; in graphics mode,

it can produce a density of 82.5 by 82.5 dots per inch.

The new Color Printer can be programmed for line spacing, forms length, inter-character spacing, tabs, margins, and automatic underline. Super- and sub-scripts are supported. Print quality can be enhanced through the use of double pass, emphasized, and offset printing.

The printer will accept three types of ribbon: black, primary, and process. The primary ribbon has four colors (red, green, blue, and black). The process ribbon has four colors (yellow, magenta, cyan, and black) that can be mixed to form four additional colors (orange, green, violet, and brown). The black ribbon supports automatic band shift, which extends its life.

Fan fold, continuous roll, or single-sheet paper may be used. The tractor feed mechanism is built in, and paper may also be fed manually. Bidirectional vertical paper motion is provided.

CIRCLE 429 ON READER SERVICE CARD

IBM has introduced two new models of the IBM Personal Computer specifically targeted for the mainframe community. The IBM Personal Computer **XT/370** is an enhanced version of the

XT that allows the user to run programs written for the VM/CMS environment. Two circuit cards containing two Motorola 68000 processors, a custom IBM chip similar to the Intel 8087, and one-half megabyte of RAM provide the capability to execute a subset of the System/370 instruction set (the most commonly used fixed point data and control instructions, along with the floating point instructions, according to IBM). A third card provides a coaxial link that allows the XT/370 to act as a 3277 Model 2 display terminal when connected to the IBM 3274 control unit.

The XT/370 executes a new control program called VM/PC, which allows a virtual memory space of up to 4 million bytes. Executable VM/CMS programs and data are loaded from a host processor. The XT/370 does not, therefore, act as a small, stand-alone System/370.

In addition to 370 and 3277 operation, the XT/370 can be used as a standard IBM PC/XT. In this mode, 384KB of the XT/370's memory can be used by the XT, bringing ther usable memory for PC applications to the limit of 640KB.

The XT/370 is scheduled for availability sometime in the second quarter of 1984.



The price of the system, including the system unit, 256KB main PC memory, display unit, 360KB diskette unit, the XT/370 circuit cards, and 10 megabytes of fixed disk, is \$8,995. With 20 megabytes of fixed disk (provided by a second 10MB fixed disk in an IBM expansion chassis) the price is \$11,690.

Three models of the **IBM 3270 Personal Computer** will be available in the first quarter of this year. This PC variant is designed to provide emulation of the IBM 3178, 3278, or 3279 display stations.

Driven by the 3270-PC Control Program, the work-station can establish up to four independent host computer sessions, one IBM DOS 2.0 PC session, and two local notepad sessions. The control program allows activity through up to seven windows, one for each allowed session, at the same time. A single keystroke transfers control from one session to any other.

The 3270-PC can communicate with IBM mainframes via the 3274 control unit. In addition, direct attachment to 4300 series systems is supported.

The 3270-PC is designated the IBM 5271. Model 2 includes 256KB of memory, the 5271 keyboard (122 keys), one 360KB diskette drive, a special display adaptor designated the 5151/5272, the 3270 system adaptor, and documentation, and lists for \$4,290. The Model 4, priced at \$5,319, includes a second floppy, 320KB of main memory, and a parallel printer adaptor. The top-of-the line Model 6 has one floppy and a 10MB fixed disk, 320KB of main memory, and printer port for \$7,180.



Display options include the standard IBM PC Monochrome display (Model 5151 at \$345) or the new 5272 Color Display at \$995. The new display uses a 14-inch, eight-color monitor to deliver a resolution of 720 by 350 pixels. The unit includes a stand that can tilt and rotate the display.

The IBM 3270 Control Program must be purchased for a one-time charge of \$300. An optional file transfer program costs \$600.

Volume purchase discounts and term leases will be available beginning this month through the IBM National Accounts Division and National Marketing Divisions. The product was developed in Kingston, NY, and is manufactured in Raleigh, NC, by the Communications Products Division.

New 3278/79 Offer-

ing. A new circuit card and software program from IBM allow the IBM PC to emulate an IBM 3279 display unit. Once so upgraded, the PC can be connected to a host computer via the IBM 3274 control unit or directly to a 4300 series processor.

IBM stated that most applications programs that work with the 3278 model 2 and 3279 color model 2A or S2A will also work with the new product. The user can switch between host processor access and PC operation with a single key. Files can be transfered in both directions between the host and PC, and the PC's printer can be used to copy screen information.

The PC 3278/79 adaptor costs \$905 and the control program \$235. Both will be available in the second quarter at quantity discounts.

CIRCLE 430 ON READER SERVICE CARD

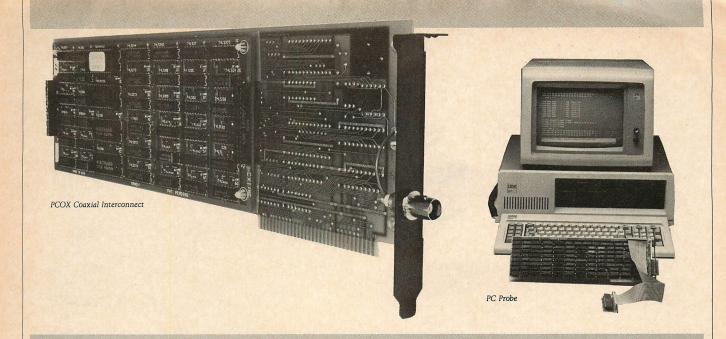
HARDWARE

A system that gives mainframe-quality graphics on the IBM PC is available from Cubicomp Corp. The CS-5 system can produce three-dimensional figures as wireframes (with or without hidden lines) or as solids with constant, flat, or smooth shading, anti-aliasing of vectors and surface edges, and texture mapping. It has a high-resolution color display, 512 x 512 pixels per frame with 12 bits of color and 4 overlay planes (16 bits per pixel), and a full megabyte of image memory. Over 4000 colors - from a palette of 16.8 million - can be displayed simultaneously. A base system starts at under

CUBICOMP CORP.
2372 Ellsworth St.
Berkeley, CA 94704
415-540-5733
CIRCLE 431 ON READER SERVICE CARD

The first Winchester disk controller for PCs to support the SMD interface commonly used in minicomputers has been developed by Interphase, Corp. The Maverick SMD PC-80 controller increases the capacity and speed of data baseserving hard disks.

Without hardware or software modifications, the Maverick can accommodate 8inch or larger disks with



fixed and/or removable cartridges, and provide almost 10 megabytes of dedicated storage to each PC in a 50-station network. Its throughput rates are three to four times that of the IBM PC-XT with a standard Winchester drive.

The Maverick occupies a single card slot, can be used with microcomputers that have architecture similar to the PC, and is compatible with most popular operating systems. \$1,895. in single quantities. \$1,200. in lots of 100.

INTERPHASE CORP.
2925 Merrell Rd.
Dallas, TX 75229
214-350-9000
CIRCLE 432 ON READER SERVICE CARD

CXI, Inc. has issued its first product: PCOX, a high-performance interface that enables the PC to emulate IBM hosts in the 3278/ 3279 series. By way of PCOX's coaxial connection, PCs access full screen host applications. A user-friendly file transfer capability, which allows transfer of data directly from the host to PC memory, and PCOX's speed are key advantages of the interface, according to company president Lou Cole. \$1,390. Without file transfer utility, \$1,195.

CXI, Inc. 10011 N. Foothill Blvd. Cupertino, CA 95014 408-725-1881 CIRCLE 433 ON READER SERVICE CARD The **IBM Electronic Typewriter 65 or 85** can now be transformed into a letter-quality printer for the IBM PC or PC XT. A circuit board installed in the typewriter, a six-and-one-half foot cable, and supporting software for the PC, affect the change.

As printers, the typewriters operate at 15.5 characters per second and accommodate 15.5" to 19.1" paper, depending on carriage width. When not online, they function as usual. \$345. for software, circuit board, cable, and installation. \$285. for circuit board, cable, and installation. \$60. for software alone.

IBM 900 King St. Rye Brook, NY 10573 914-934-4828 or 800-426-2468 CIRCLE 434 ON READER SERVICE CARD

Program Execution Analyzer (PXA) from Micro Integrations Incorporated is a single plug-in board that allows real-time dynamic analysis of a running program. The PXA board contains a resident event buffer of 1024 events before and after a user defined trigger qualifier and a video section that supports either a dedicated or shared CRT monitor for the display of event information. The information in the buffer

can be displayed, scrolled, or printed. \$750. Optional monitor, add \$100. Optional 4096 Event Memory, add \$200.

MICRO INTEGRATIONS ENGINEERING CORP. 11 Clearbrook Rd. Elmsford, NY 10523 914-592-8989 CIRCLE 435 ON READER SERVICE CARD

Now, up to 1 gigabyte (1000 megabytes) of memory of storage can be attached to an IBM PC or compatible. **National Memory Systems Corporation's PC-8000** does it, by way of a controller and one or two disk drives with from 16 to 500 megabytes each.

NATIONAL MEMORY SYSTEMS CORP. 355 Earhart Way Livermore, CA 94550 415-443-1669 CIRCLE 436 ON READER SERVICE CARD

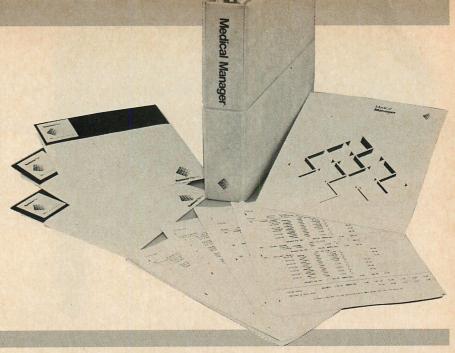
A hardware/software debugging tool for the PC and compatible systems has been introduced by Atron Corp. The PC PROBE consists of a printed-circuit card that fits into any PC card slot, a cable and probe that plugs into the 8088 IC socket, and sophisticated debugging software on floppy disk. The PROBE's software is completely contained on 64K of board RAM with memory protection. The 24 types of real-time hardware breakpoints can implement 8 breakpoints at once. Once a breakpoint has been reached, PROBE can execute a realtime trace of the previous 1024 instructions. According to the manufacturer, all languages that produce programs with PC DOS version 2.0 object-module formats can be debugged with PC PROBE, including Macro Assembler, Pascal Compiler, FORTRAN Compiler, and C Compiler. \$1,595.

ATRON CORP. 20665 Fourth St. Saratoga, CA 95070 408-741-5900 CIRCLE 437 ON READER SERVICE CARD

Northwest Instrument Systems' Interactive State Analyzer

(ISA) can now be connected to Apple computers and IBM PCs. ISA combines data acquisition and measurement capabilities with a PC's operating system, storage, computation, and control functions. Its multilevel, state-machine architecture can operate in 15 independent trigger/store states. Storage qualifiers on each state permit local control of stored data. \$2,995, with 4 kilobits storage for each channel. Additional 16channel cards, \$895.

NORTHWEST
INSTRUMENT SYSTEMS, INC.
P.O. Box 1309
Beaverton, OR 97075
503-297-1434
CIRCLE 438 ON READER SERVICE CARD





From Caere Corp. comes the 240 Bar Code Scanner, a wand that reads bar codes and enters them in IBM PC or XT programs. Programs written to accept keyboard input accept input directly from the scanner because of Caere's keyboard interface circuit board. Bar code printing software will also be available. \$745., with standard resolution pens. \$785., with high resolution pens. \$179. for bar code printing software.

CAERE CORP.
100 Cooper Court
Los Gatos, CA 95030
408-395-7000
CIRCLE 439 ON READER SERVICE CARD

The Database Machine® from COGENT Data Technologies, Inc. is an intelligent, high-speed controller for Winchesters acting as network servers. Installed in a slot of a PC, the product sorts requests from micros on the network, provides data base programs, and accesses the hard disk. Suggested retail price, \$1,300.-\$1,500., de-

pending on configuration and quantity.

COGENT DATA
TECHNOLOGIES, INC.
P.O. Box 3902
Bellevue, WA 98009
206-455-3343
CIRCLE 440 ON READER SERVICE CARD

A new multibus interface adapter, the PIX-690A, has been added to the Modular Integration line. The adapter, an iSBX-compatible board, provides an interface between an Intel Multibus 8 or 16-bit CPU and Modular's process bus. Because the adapter rides resident on the Intel CPU board, applications programs can be developed in compatible languages such as PLM, CPM, Pascal, and C. All of Modular's high-speed, process I/O cards may be accessed from a CPU resident in the Multibus chasis.

Also from Modular is the LINK/110, a PC-based process control system for use in water and waste water treatment, and in the oil and gas, food and beverage, and power industries. The LINK/110 system can be expanded to support up to 64 analog inputs, 32 analog outputs, and 256 discrete inputs and outputs. An assortment of process interface cards are available, among them an analog to digital multiplexor, DC output, AC output, universal contact input, pulse train

output, and analog loop output. Systems range from \$5,000. to \$10,000. (including IBM PC).

MODULAR
INTEGRATION, INC.
P.O. Box 1079
Issaquah, WA 98027
212-392-8086
CIRCLE 441 ON READER SERVICE CARD

CONOGRAPHY®, an advanced graphics technology, increases the PC's flexibility when it comes to building images. By creating images with less data, CONOGRAPHY allows for faster processing with reduced storage. The technology uses conic curves for graphics and motion control; curves are drawn directly rather than being approximated with straight line segments. And because graphic descriptions are independent of things such as horizontal and vertical resolution, objects can be reproduced on different devices or computers (with an appropriate graphics driver).

The system includes the CONO-COLOR® adapter, which provides 16 colors and



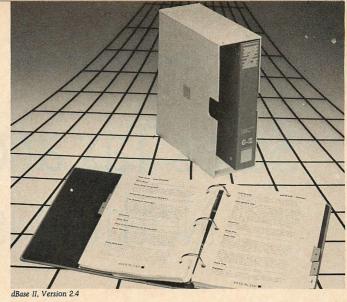
high resolution; the CONO-GEN® module, which increases processing power and speed; CONO-CURVE®, the base software for the system; and CONO-LIB®, the supporting utility. \$895. for standard CONO-COLOR adapter. \$395. for CONO-CURVE (currently including CONO-COLOR at no additional charge). \$200. for CONO-LIB.

CONOGRAPHIC CORP.
2268 Golden Circle
Newport Beach, CA 92660
714-474-1180
CIRCLE 442 ON READER SERVICE CARD

SOFTWARE

Systems Plus, Inc. has released an office management module for its Medical Manager®, which can report, at any time, data on all aspects of a patient's medical history and the physician's schedule. Office management information is stored and reports are generated in five categories: hospital rounds, clinical history, procedure and diagnosis history, frequency and revenue, and appointments and recall management. Medical Manager requires CP/M-80, CP/M-86, MP/M-80, or MP/M-86 system with at least 64K. Hard disk storage is recommended. \$4,000-





\$8,000, depending on amount of dealer support. SYSTEMS PLUS INC. 1120 San Antonio Road Palo Alto, CA 94303 415-969-7047 CIRCLE 443 ON READER SERVICE CARD

SofTech Microsystems recently announced its Liaison family of network software products that includes UCSD p-System operating environment, disk and print server software, application packages, and a set of development tools for designing customized distributed software packages. Liaison is an open system: the architecture is fully documented and software developers are encouraged to use the information, and help from SofTech, to write application software.

Hardware independent, Liaison will be available from SofTech, OEM's, software developers, and selected network hardware suppliers. Liaison is currently compatible with Corvus Systems Omninet, and SofTech has signed an agreement with Corvus Systems to market Liaison. Negotiations for similar arrangements are currently underway with 3COM and Nestar. A network media kit is available to support the adaptation of Liaison to other network hardware.

The software is designed

around the concept of a dynamic network in which the relationship among workstations changes frequently. This allows for a very flexible network design in which a workstation can act as a client or server, depending on the application involved.

Five applications programs have been released in the Liaison family: electronic mail, query data base, word processing, spreadsheet, and executive calendar. All these programs feature on-line documentation, multiple colored windows, and a standard user interface.

To answer the problem of software developers troubled by potential piracy problems, SofTech has developed a concurrent use polling device called the Liaison Monitor. It controls the number of simultaneous users of a particular program, giving developers control over licensing and sales income.

Over twenty software developers have committed to writing Liaison applications packages. Shipment of Liaison software is scheduled to begin in February, 1984.

SOFTECH MICROSYS-TEMS INC. 16885 West Bernardo Drive San Diego, California 92127 (619)451-1230 CIRCLE 444 ON READER SERVICE CARD Avocet Systems, Inc. has cross-assemblers for the IBM PC. Available under both the MSDOS and CP/M-86 operating systems, the assemblers cover 11 microprocessors: 6805, 6809, 1802/ 1805, 8048/8041, 8051, 6502, 6800/6801/6301, NEC7500, F8/3870, COP400, and Z8. Assemblers for the 8085 and Z80 processors were to be released in the fall. \$250 to \$500.

AVOCET SYSTEMS 804 South State St. Dover, DE 19901 302-734-0151 CIRCLE 445 ON READER SERVICE CARD

Primivera® Project Planning is software that provides critical path method analysis, resource leveling, and cost control for computer users who had previously relied on less cost-effective mainframes or large minicomputers. Based on PRO-MAC/90 software, Primivera can make project planning and control techniques available to a broader cross-section of users who need to accommodate up to 10,000-activity networks. \$2,500.

PRIMIVERA SYSTEMS 29 Bala Ave., Suite 224 Bala Cynwyd, PA 19004 215-667-8600. CIRCLE 446 ON READER SERVICE CARD dBASE II, Version 2.4 is now available from Ashton-Tate. The new version of this relational database system includes an on-disc tutorial, which, in 10 lessons, acquaints users with the principles and theory of general database management while providing valuable hands-on experience.

ASHTON-TATE 10150 Jefferson Blvd. Culver City, CA 90230 213-204-5570 CIRCLE 447 ON READER SERVICE CARD

VisiCorp has further extended the performance of its electronic spreadsheet software with VisiCalc® IV program. It integrates all the standard VisiCalc features with graphics, sorting, spreadsheet management, and exclusive Keysaver® capabilities for user-defined commands. With the new graphics commands, users can convert spreadsheet data into one or more of eight graph options. Complex or special graphs generated through a series of keyboard commands programmed by the user can also be stored on the data diskette and later retrieved. \$250.

VISICORP 2895 Zanker Road San Jose, CA 95134 408-946-9000 CIRCLE 448 ON READER SERVICE CARD

Sales Tax and Software: Nothing is Simple

Some states tax software and some don't.

It all depends on whether software is more like a phonograph record or more like your first grade teacher.

MAX STUL OPPENHEIMER

Here's a tax tip: The next time you are in the mood for some country and western music, consider hiring "Alabama" to perform in your living room instead of buying a bunch of their records. In most states, there would be a sales tax on the records, but not on a personal performance. Sophisticated tax lawyers call this "letting the tax tail wag the dog." In structuring a software transaction, the tail can grow to significant size, and recent court and administrative decisions have made it a creature to be reckoned with in several states.

The issue is easy to frame. In most states, some sort of tax is imposed on tangible personal property (but not on intangible property or personal services). This tax may be imposed either at the time of purchase (as a sales tax) or as an annual fee (for example, as a corporate franchise tax). Is computer software tangible personal property?

The answer is this: It depends.

PRECEDENT AND ANALOGY

To understand why, two fundamental concepts of common law must be explained: precedent and analogy. The concept of precedent means that a judge will not do anything that another judge has not already done. The entire system would collapse in a grand RETURN without GOSUB error but for the concept of analogy, which means that a judge can do something that no other judge has done before if he can find a judicial decision that is analogous to the one he proposes to make. Considering that there are always at least two parties to a case, a judge can usually expect to be offered two or more analogies. The outcome of a case is frequently determined by which party has succeeded in persuading the judge to accept his set of analogies.

Watch how analogies simplify the problem. Surely, the sale of a phonograph record is subject to sales tax (assuming your state has a sales tax). Equally as certainly, no one would suggest that you should pay sales tax on the knowledge you acquired in first grade. The problem now is simply whether software is more like a phonograph record or your first grade teacher.

In a series of cases, the state courts of Tennessee (1976),* Alabama (1977), Illinois (1981), and Missouri (1982) all held that software was not subject to sales (or similar) taxes. While each court stressed particular facts peculiar to the case before it, all of them essentially viewed the transaction as a sale of knowledge and saw the tangible medium on which the knowledge was stored as incidental. Each court noted that the knowledge could have been obtained by clearly non-taxable means, such as direct entry of the programs at the keyboard or remote transmission of the program to the user's computer. Since the tangible medium on which the data was stored was viewed as incidental, no tax on tangible personal property was due (except for the tax on the value of the blank medium).

However, no state court is bound

Max Stul Oppenheimer is a practicing attorney.

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CIRCLE NO. 113 ON READER SERVICE CARD

Legal Brief

by the analysis of an issue by another state's court. Recently, the courts of Vermont and Maryland reached the opposite conclusion.

In Vermont, the court accepted the proposition that alternative, non-taxable means of transferring the programs could have been used, but noted that they weren't what the parties chose to use. The Maryland court made the same observation and also questioned whether the purchase of a book or record (clearly taxable transactions) could not also be said to be purchases of "knowledge."

Following the decisions in the Vermont and Maryland cases, the Attorney General of Virginia issued an advisory opinion stating that canned software was tangible personal property under Virginia law.

In the purchase of a \$25 computer game, the issue is not significant, but if you write or buy custom software, sales tax should be considered when you negotiate the transaction in the above cases, Tennessee and Missouri each wanted about \$4,000 in taxes; Michigan more than \$8,000; Illinois more than \$12,000; and Alabama more than \$13,000.

Specifics depend on which state is involved, but the cases decided to date suggest some general approaches. All of the cases above noted the distinction between "operational" and "transactional" software. The Tennessee court offered the following definition: An "operational program. . .controls the hardware and actually makes the machine run"; an applicational program" is "designed to perform specific functions such as preparation of the employee payroll, preparation of a loan amortization schedule, or any other specific job."

If the distinction does not seem quite clear, remember that the opinion was written in 1976. It may also be reassuring that none of the courts seems to do anything more than state the distinction. If there is a difference (I don't see one), operational software is arguably more a part of the machinery than operational software

and thus more "tangible."

Software escapes the tax on tangible personal property if (a) it is not property, but rather a service, or (b) it is property, but not tangible.

n a series of cases, state courts of Tennessee, Alabama, Illinois, and Missouri all held that software was not subject to sales taxes. Vermont and Maryland reached the opposite conclusion.

The greater the degree of customization, the stronger the argument that what is being sold is a service rather than tangible personal property. When furnishing a custom program (or customizing an existing program), keeping records of the effort involved in creating or adapting the specific program may be a significant aid in arguing against taxability.

All of the courts seem to have assumed that sales tax would not apply to transmission of a program over communications lines. The courts seem also to have accepted that sales tax would not apply if the seller arrived at the purchaser's place of business and keypunched the program directly into the user's machine. These hypothetical assumptions were made as part of the court's analysis, but were not part of the court's decision (since the hypothetical case was not before the court).

Often, the telecommunication technique will be feasible and, if the sales tax can thereby be avoided, the savings may make the effort worthwhile. The keypunch alternative is not likely to be feasible, but it does suggest some close analogies that might be. For example, if the user could avoid the sales tax by having an employee keypunch the data directly into the machine, perhaps he could also avoid it by having an em-

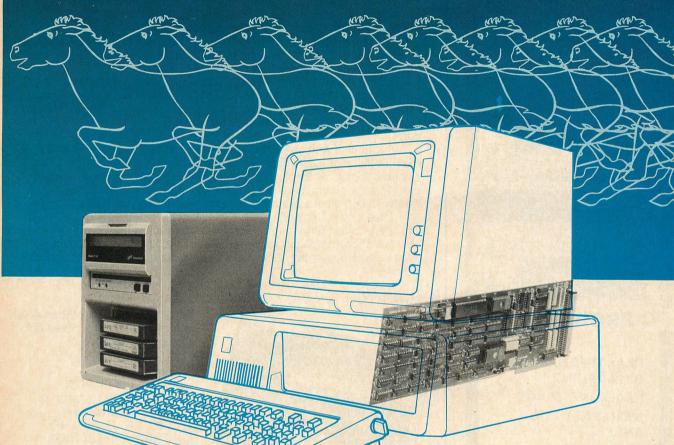
ployee borrow a disk containing the program, load it into the user's machine, and return the disk. In that case (as presumably in the keypunch case), the owner of the program would be paid a fee for the use of his information. It is but a small step from this technique to the more straightforward one of simply paying the vendor a fee for bringing his software to the user's location, loading it into the user's machine and taking his tangible medium back with him. The user could then simply make his own copy of the program on his own storage device. For any of the techniques to work, of course, the vendor must provide software in copyable form, and he should expect, in return, a reasonable secrecy agreement from the purchaser.

None of these techniques has been tested in the courts, and cynics might suggest that what is at issue is not whether software is tangible, but simply whether it is available as a source of tax revenue. If it is, then notwithstanding the court's hypothetical assumption that such techniques would avoid the sales tax, a cynic would expect the court to reconsider when a specific case was before it.

With this possibility in mind, there should be one final question asked in the negotiation of the sales tax aspects of a software agreement: if the tax collector disagrees with the parties' conclusion that it is not taxable, which party pays?

*For those who are interested, the citations for the cases are Commerce Union Bank v. George M. Tidwell, Commissioner of Revenue, State of Tennessee, 538 S.W.2d 405 (Tenn. 1976); In Re State of Alabama v. Central Computer Services, Inc., 349 So.2nd 1160 (Ala. 1977); First National Bank of Springfield v. The Department of Revenue, 421 N.E.2d 175 (Ill. 1981); and James v. Tres Computer Systems, Inc., et al., 642 S.W.2d 347 (Mo. 1982). The Michigan (MacCabees Mutual Insurance Company v. State of Michigan), Maryland (Comptroller of The Treasury v. Equitable Trust Company) and Vermont (Chittenden Trust v. King) cases have not been published in the official reports yet.

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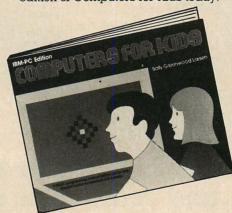
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January 15-18

Eleventh Annual ACM SIGACT-SIGPLAN Symposium on Principles of Programming Languages Salt Lake City, UT

Sponsor: ACM SIGACT and SIGPLAN Contact: Mary Van Deusen, 34 Archer St., Wrentham, MA 02093, 617-384-2526

January 31-February 3

Sixth Annual Communication Networks Conference and Exposition

for the Telecommunications
Business Professional
Washington, DC

Contact: CN '84, Box 880, Framington, MA 01701, 617-879-0700

FEBRUARY

February 14-16

ACM Annual Computer Science Conference Philadelphia, PA

Sponsor: CM Contact: Frank L. Friedman, Dept. of Computing and Information Science, Temple University, Computing Center Bldg. 303, Philadelphia, PA 19122, 215-787-1912

February 20-22
Office Automation

Conference Los Angeles, CA

Sponsor: American Federation of Information Processing Societies Contact: AFIPS, 1815 N. Lynn St., Arlington, VA 22209, 703-558-3617

February 21-23

Softcon: The International Conference and Tradefair for the Software Industry New Orleans, LA

Contact: Northeast Expositions, 822 Boylston St., Chestnut Hill, MA 02167, 617-739-1000 or 800-841-7000

MARCH

March 23-25

West Coast Computer Faire San Francisco, CA

Sponsor: Computer Faire Inc. Contact: 570 Price Ave., Redwood City, CA 94063. 415-364-4294

March 26-28

7th Intl. Conference on Software Engineering Orlando, FL

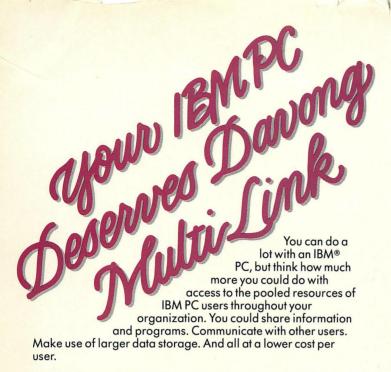
Sponsors: ACM SIGSOFT, IEEE, Natl. Bureau of Standards Contact: Robert Fritz, Telesoft, 10639 Roselle St., San Diego, CA 92121, 714-457-2700

APRIL

April 9-12

TEEE Infocom 84 San Francisco, CA

Sponsors: IEEE-CS, IEEE
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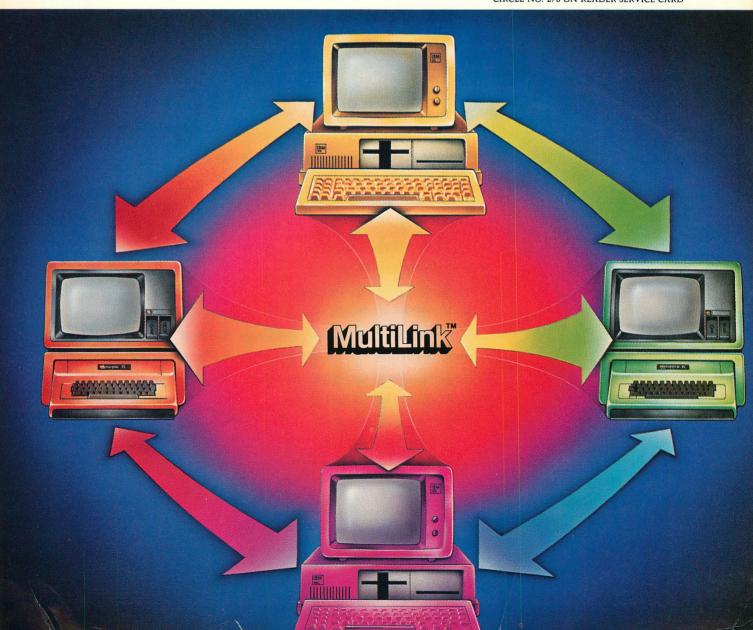
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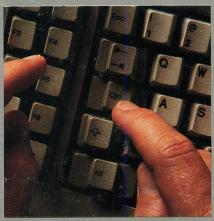
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